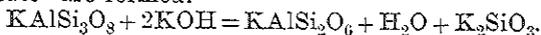


ABSTRACTS AND REVIEWS

I.—Glass-making Materials.

1. A New Method for the Recovery of Salts of Potassium and Aluminium from Mineral Silicates. J. C. W. FRAZER, W. W. HOLLAND, and E. MILLER (*J. Ind. Eng. Chem.*, 1917, 9, 935).—In silicates such as felspar and sericite, the method finally adopted by the writers secured the transformation of felspar by successive stages into products analogous to certain well-defined minerals occurring in nature.

A quantity of finely ground felspar (about 50 mesh) is treated with about 0·8 of its weight of potassium hydroxide or an equivalent amount of sodium hydroxide, the mixture is heated in an open iron vessel until the water has evaporated, and thereafter for a period of about one hour at about 275—300°, when a new silicate of the composition of leucite and also an equivalent quantity of alkali silicate are formed.



Leucite is insoluble in water, and may be separated from the soluble portion, which consists of the excess alkali used for decomposition and the alkali silicate simultaneously produced. The alkali employed in bringing about this reaction can be entirely recovered by causticising the solution with lime and filtering off the calcium silicate which is precipitated.

The "artificial leucite" can be made to yield its constituents one at a time by treatment with acids, thus avoiding expensive methods of separation by evaporation, crystallisation, etc., and it is possible to obtain the potassium directly as chloride, sulphate, or nitrate without the removal of the aluminium. For this extraction, the silicate is mixed with water, and the diluted mineral acid in amount equivalent to the potassium content of the silicate is added slowly with constant stirring. Local excess of acid must be avoided, or a portion of aluminium may be brought into solution. The potassium salt is removed from the insoluble silicate of aluminium by filtration. This insoluble silicate is somewhat analogous to kaolinite, the final product of the weathering of felspar. If this silicate is now treated with an amount of sulphuric acid equivalent to the aluminium content, aluminium sulphate is produced and gelatinous silica separates. After dehydrating the silica, the sulphate is dissolved in water and separated by filtration.

The same product is obtained by the treatment of other silicates, such as sericite and clay.

The yield of potassium chloride is practically theoretical; the yield of aluminium sulphate is about 86 per cent. of the theoretical.

Hence it can be seen that in normal times the aluminium sulphate is more valuable than the potassium chloride produced, and under these conditions the process is an aluminium sulphate process with potash as a by-product.

C. M. M.

2. The Recovery of Water-soluble Potash as a By-product in the Cement Industry. WILLIAM H. ROSS and ALBERT R. MERZ (*J. Ind. Eng. Chem.*, 1917, **9**, 1035).—It is estimated that the total potash (K_2O) escaping from all the cement plants in the United States as at present operated will amount to about 87,000 tons annually. The process which at present is most generally considered in connection with the recovery of the potash that escapes from cement kilns is that of electrical precipitation. With present installations, a recovery of approximately 99 per cent. of the dust has been secured. It happens, however, that the finest portion of the dust escaping from any cement plant contains relatively the highest percentage of potash, and a 99 per cent. recovery of the dust therefore represents a somewhat less efficient recovery of the potash.

Potassium compounds occurring in cement dust may be divided into those which are readily soluble in water, those which are slowly soluble, and those which are insoluble. The insoluble potash represents the combinations occurring in the original silicates of the raw materials which are carried over mechanically in the dust. The form of combination which is slowly soluble in water is supposed to be due to a recombination of the volatilised potash with the silicates in the dust.

In cement dust, as it escapes from the kilns, the slowly soluble and insoluble potash are already associated with a considerable percentage of free lime. Hence it has been suggested that the greater part of these constituents might be recovered in readily soluble form by digesting the dust with steam alone under pressure. It has been found possible to recover in this way, in soluble form and with little increase in pressure, about 95 per cent. of the total potash present.

At one plant, an increase in the potash volatilised has been brought about by addition of ordinary salt in the solid state, both to the raw mix and to the coal used for fuel. The resulting cement is in no sense impaired, and it is found that the total alkalis in the clinker are actually less than when no salt is added. By this treatment, the percentage of volatilised potash has been increased from 35 per cent. to 65 per cent. Another reagent is calcium fluoride, which can be fed into the furnace again and used repeatedly in bringing about increased volatilisation of the potash. By this cyclic process, the volatilisation has been increased from 60 per cent. to 90 per cent.

C. M. M.

3. The Viscosity of Blast-furnace Slag and its Relation to Iron Metallurgy, including a Description of a New Method of Measuring Slag Viscosity at High Temperatures. A. L. FIELD (*Trans. Faraday Soc.*, 1917, **13**, 3).—Furnacemen long

ago noticed that, on heating, slag underwent a gradual softening rather than a sudden change to a mobile liquid, as does, for example, sodium sulphate. They associated this property more with the silica present than with the alumina, or lime.

High viscosity is a common property of silicates, and this is probably due to the nature of the silica molecule. The relatively high viscosity of molten glass, as compared with that of molten metals and ordinary salts, is due to the preponderance of the group molecules of silica, alumina, and lime, and possibly to a particularly large degree on the highly polymerised condition of the silica group molecule.

The viscosity determinations were carried out by a modification of the Margules method, a full description being given in the paper.

The author also carried out determinations of softening temperatures and analyses of eighteen commercial slags. The softening temperatures of the slags were determined in a platinum wire resistance furnace. It is pointed out that the softening temperature is often far removed from the true physical melting point.

The author found from his experiments on eight commercial slags, two synthetic slags, and an artificial diopside ($\text{CaO}, \text{MgO}, 2\text{SiO}_2$) that the temperature-viscosity curves approximate to the form of a rectangular hyperbola, whereas the temperature-fluidity curves approach a straight line in form.

A slag possessing a high softening point is not necessarily more viscous at high temperatures than a more fusible slag. This is shown by table 2.

TABLE 1.

Percentage Composition of Slags.

No.	SiO ₂	Al ₂ O ₃	FeO	Fe	TiO ₂	CaO	MgO	MnO	CaS	Alkalies	Moisture
1	43.56	9.48	0.21	0.38	0.19	40.18	2.08	0.21	2.75	0.50	0.05
2	37.18	11.46	0.31	0.11	0.52	25.33	19.58	2.21	3.51	—	0.04
3	33.67	26.62	0.28	0.51	0.28	26.67	6.43	0.33	4.86	—	0.12
4	34.27	13.78	0.07	0.28	0.56	41.30	6.39	0.55	3.35	—	0.04
5	18.30	35.30	0.47	0.05	0.58	31.24	9.69	0.35	4.07	0.50	0.02
6	31.54	14.79	0.07	0.22	0.29	47.65	1.80	0.21	3.56	—	0.10

TABLE 2.

No.	Softening temperature.	Viscosity at		
		1,400°	1,450°	1,500°
1	1,279°	1,000	680	480
2	1,297 to 1,300°	510	380	280
3	1,342	510	350	260
4	1,343 to 1,360	460	350	280
5	1,410	750	410	230
6	1,403 to 1,443	3,000	480	380

Table 1 gives the compositions of six slags and table 2 their softening temperatures (for several specimens) and viscosities, the slags being arranged in the order of their refractoriness.

In expressing the viscosity results, the viscosity of water at 20° is taken as 1.

On studying the softening temperatures and compositions of the eighteen slags examined, it was found that low softening temperatures are, in general, associated with high silica content. Rankin and Wright (this Journal, 1917, 1, A., 142) found that the minimum ternary eutectic of the system lime-alumina-silica contained CaO 23.25, Al₂O₃ 14.75, and SiO₂ 62 per cent., and melted at 1170°. It would follow, therefore, that in all slags which possess more than the usual amount of silica there is formed on incipient fusion a large amount of a low-melting eutectic, which, when it attains a sufficiently low viscosity, causes the test-piece to soften visibly and deform. Therefore high silica slags, which are known to be more viscous at furnace temperatures than more basic slags, possess, quite paradoxically, low softening temperatures.

Table 2 shows that, of the six slags quoted, No. 1 has the lowest softening temperature but the highest viscosity at 1500°. It might also be noted that the artificial diopside contains 55 per cent. of SiO₂, melts at 1392°, and has a viscosity of 640 at 1500°, whilst a synthetic slag containing SiO₂ 48 per cent. has a viscosity of 770 at 1500°.

The high alumina content of slag No. 5 causes it to have a high softening temperature, but does not have any noticeable effect in increasing the viscosity at high temperatures.

Up to the present, sufficient results have not been obtained to discuss the effect of the bases present in the slag on the softening temperature and viscosity. Viscosity measurements, however, have been made with two synthetic slags, (a) containing CaO 48 per cent., and (b) containing CaO 28 per cent. and MgO 20 per cent., the other constituents being the same. The slag (b) had the lower viscosity at all temperatures between 1250° and 1500°.

The literature on slag viscosity and high temperature viscosity measurement is briefly reviewed. J. D. C.

II.—Glass: Manufacture and Properties.

4. The Effect of Antimony Compounds in Glass Batches.

L. SPRINGER (*Sprechsaal*, 1915, 48, 211).—In amplification of a previous paper on this subject (*Sprechsaal*, 1915, 48, 97), the author gives the results of a series of laboratory experiments on the effect of antimony when used with lime-soda and lead-potash glasses. The batches used were respectively:—

Lime-soda glass.				Lead-potash glass.			
Sand	...	...	150 parts	Sand	...	...	150 parts
Calcium carbonate	...	20	..	Red lead	...	...	100
Sodium carbonate	...	60	..	Potash	...	...	60

Pure materials and the purest glass sand obtainable were used. The results of the experimental melts show that white antimony oxide, even when present in comparatively large quantities, exerts no colouring effect on either lead- or lime-glasses, and consequently is not of value as a decolorising agent.

Metallic antimony produces a very faint bluish tint in both types of glass. If present in quantity, a considerable proportion of the antimony separates out on the bottom of the pot and corrodes it badly.

Antimony sulphide produces a yellow colour in both types of glass, the colour being irregular with the lead glass. The tint produced is deeper when the sulphide of antimony is added to the metal after fusion instead of being mixed with the batch.

Naples-yellow (lead antimoniate) produces no colour in lime glasses, and only a very faint yellow tint in lead glasses, which is not in accord with the general opinion that Naples-yellow produces a strong yellow tint in the glass.

Several of the melts were analysed to determine the amount of antimony left in the glass, and the author finds that practically the whole of the antimony oxide added—whether much or little is present—passes into the glass, and consequently cannot assist the fining process.

The general conclusion drawn is that the addition of small quantities of antimony to glass batches is useless, and can be discontinued without any difficulty arising.

J. H. D.

5. New Experimental Melts with Saltpetre Substitutes.

L. SPRINGER (*Sprechsaal*, 1917, 50, 39 and 49).—The first experiments were made with a saltpetre substitute supplied by Schott and Genossen, Jena. No account of the substitute is given. The experiments were carried out in order to test its decolorising action, and one part of it was used for every 100 parts of sand in the batch.

The material was found to be as successful as saltpetre in decolorising soda-lime and lead-potash glasses, and when it was present in the batch less decoloriser was needed to obtain a white glass. The decoloriser used was a mixture of nickel oxide and sodium selenate. With salt-cake glasses, good decolorising results were only obtained when the salt-cake batch was first melted down until all the salt-cake had been decomposed, the substitute and decoloriser, mixed with sand, lime, and soda ash, then being added and the melt stirred.

The second series of experiments was carried out with barium peroxide, containing about 87 per cent. of barium peroxide. In the majority of the experiments, the barium peroxide used was equal to 2 per cent. of the sand in the batch. Experimental batches were made up of pure materials, and iron was added to them either as ferric or ferrous oxide.

In lime glasses, when ferric oxide is present, the barium peroxide exerts a decolorising action, the colour being weakened and changed

in tint from a bluish-green to a less conspicuous yellowish-green. On the other hand, if ferrous oxide is present, barium peroxide, even in large quantities, has no apparent decolorising effect. In practice, the iron is usually present as ferric oxide and in less quantities than that used in these experiments; therefore barium peroxide should prove a suitable saltpetre substitute for lime glasses.

In lead glasses, ferric oxide produces a bluish-green colour and ferrous oxide imparts a yellowish colour. With heavy lead glasses, barium peroxide has no decolorising effect, being effective only with glasses of low lead oxide content, such as half-crystal glass.

J. D. C.

6. The Classification of Illuminating Glasses. (*Sprechsaal*, 1917, 50, 90).—The Technical Physics Section of the Reichsanstalt proposes that the suitability of a glass for illuminating purposes be judged on the basis of its coefficient of expansion. This applies only to glasses used for protecting flames, and not to those used for electric globes. The following classification is suggested:—

Class.		Linear coefficient of expansion.	Description.
1	...	0 to 35×10^{-7}	High heat-resistant glass
2	...	36 to 45×10^{-7}	Good
3	...	46 to 55×10^{-7}	Fair
4	...	56 to 65×10^{-7}	Weak
5	...	66×10^{-7} and higher	Inferior

The coefficients of expansion referred to are the mean values between 0° and 100° .

J. D. C.

7. The Colouring Effect of Iron Oxide in Glass Batches. (*Sprechsaal*, 1917, 50, 109).—Iron oxide (also used as “colcothar,” “caput mortuum,” etc.) may give a yellowish or green tint to glass, according to the quantity present, the nature of the batch, and the furnace conditions. Under reducing conditions, and particularly in tank furnaces, the tendency is to produce a green colour. The more basic the glass is, particularly with lead glasses melted in pot furnaces, the stronger is the tendency to produce a yellowish colour. In conjunction with manganese, all shades may be produced from a light yellow to a dark orange-brown. The temperature of the furnace and the time the glass is subjected to the full heat also affect the resulting colour.

J. H. D.

8. Opal Glasses from Cryolite or Cryolite Substitutes. (*Sprechsaal*, 1917, 50, 125).—Owing to the difficulty of obtaining natural cryolite, “artificial cryolite” and similar substitutes may be used. Sodium silico-fluoride is recommended in some batches, whilst various patent mixtures, of which this is probably the basis, are also suggested for the production of a “milk” or opal glass.

Numerous recipes are given, of which the following may be taken as examples:—

	I	II
Sand	100 parts	120 parts
Soda ash	20 ..	30 ..
Potash	4 ..	5 ..
Saltpetre	4 ..	—
Red lead	8 ..	—
Fluorspar	20 ..	22 ..
Felspar	30 ..	8 ..
Alumina	10 ..	—
Cullet	20 ..	—
Artificial cryolite		12 ..

These "spar" glasses have rather a pronounced action on the pots in consequence of their fluoride content. They should be made up rather soft, *i.e.*, readily fusible, and should be worked out as soon as ready and not heated any longer than necessary, as excessive heating tends to reduce the opacity and produce clear glasses.

J. H. D.

9. Cherry-red Glass, direct from the Pot (*Sprechsaal*, 1917, 50, 126).—Two receipts are given for the production of a red glass for beads, copper being the colouring agent in each case.

The first receipt is as follows:—

Sand	100 parts	Cream of tartar	2 parts
Potash	30 ..	Cuprous oxide	6 ..
Borax	7 ..	Stannous oxide	6 ..
Saltpetre	5 ..	Iron oxide	0.5 ..
Red lead	20 ..		

The batch must be very finely powdered and intimately mixed. After a melting period of about six hours in a hot furnace, during which the glass is "bubbled" two or three times, the contents of the pot are ladled into cold water, dried, powdered, and mixed with an equal weight of a lead batch or of lead glass cullet and again melted. The colour is intensified by annealing the finished articles in a lehr directly coal-fired.

J. H. D.

10. Barium Carbonate as a Constituent of a Glass Batch (*Sprechsaal*, 1917, 50, 148).—A discussion on the possibility of substituting potash by barium carbonate in a batch for table ware. The following opinions are expressed:—

(1) Potash cannot be substituted directly by barium carbonate, but the use of the latter as a substitute for part of the lime leads indirectly to a saving in potash, since the resulting batch melts and founds more easily, and a reduction can therefore be made in the amount of alkali used.

(2) Barium carbonate may be used as a substitute for either lime or lead, and its effect on the physical properties of the glass is intermediate between that produced by these oxides. The substitution of part of the lime by baryta yields a heavier, brighter glass which melts and fines more readily, and has a better appearance when finished.

J. H. D.

11. Glasshouse Pots for Sheet Glass. (*Sprechsaal*, 1917, 50, 125).—In a discussion on the best clay mixture for making open pots for melting a salt-cake batch for sheet glass, the opinions expressed are practically unanimous that the proportion of raw to burnt clay should not be more than 5:6. A more plastic mixture would give pots more resistance to attack by the glass, and particularly by the "gall" or "salt" which always appears to a greater or less extent on the surface of a salt-cake batch, but such pots would be more liable to crack under the influence of the temperature changes encountered in sheet-glass production.

The sides of the pots should be fairly thick towards the top, on account of the action of the "salt," and should be thoroughly well "thumped" during construction to produce as close and solid a mass as possible.

Several mixtures are quoted, German clays being referred to in each case. J. H. D.

12. Open Glasshouse Pots for Melting Sheet Glass. (*Sprechsaal*, 1917, 50, 270).—A discussion in which considerable divergence of opinion is apparent. Some glass-makers prefer a pot as thin as possible, arguing that the heat gets through to the metal more quickly, that there is less loss owing to batch cracks, and, after being emptied, a thin pot can be much more rapidly heated up again and be ready for filling in than a thicker one. Others, however, prefer a stronger and heavier pot, chiefly on account of its mechanical strength. The upper edges should not be too thin, on account of the corrosive action of the salt-cake.

For a glass pot having an upper diameter of 105 cm. and a height of 75 cm. (inside dimensions), the thickness of the side wall and bottom recommended vary between the limits

Side walls at top.....	60—100 mm.
.. at bottom	75—120 ..
Bottom	85—120 ..

Many glass-makers prefer a broader, shallower glass pot, being of the opinion that the fusion and fining processes take place more rapidly in such a pot. It is claimed that a pot having 120 cm. top diameter and 60 cm. height would melt and fine the same quantity of glass as the pot mentioned above in three hours' less time, and also be easier to manipulate. J. H. D.

13. Contribution to the Chemical Study of Coloured Glass of the Middle Ages. G. CHESNAU (*Compt. rend.*, 1915, 160, 622).—Glasses of four colours, violet, blue, green, and red, from Rheims Cathedral, dating from the thirteenth century, were analysed. They were lime-potash glasses, and the first three were coloured throughout, the colour of the fourth being obtained by a thin layer of enamel. When powdered, they were attacked by acids, although they had resisted atmospheric conditions.

It was found that the violet glass, besides manganese in the form of Mn_2O_3 , contained iron oxide and traces of copper and

cobalt, which are generally associated with manganese in impure pyrolusites. The blue glass contained 3 per cent. of manganese as protoxide, and some copper and cobalt. It had apparently been coloured with zaffre obtained from native arsenio-sulphide of cobalt. The absence of nickel, which produces a dark discoloration, shows that in the thirteenth century it was known how to avoid its presence in zaffre. The colour of the green glass was produced by the oxides of iron and copper, the particular shade being obtained by the addition of manganese. In the case of the red glass, the colour of the enamel was due to cuprous oxide. Without this enamel the glass was of a clear green colour.

The potash content of the violet and green glasses was higher than that of the other two. This was probably due to the necessity for working in an oxidising atmosphere in order to obtain violet with manganese and green with copper, more nitre being added to the ordinary batch to counteract the reducing effect of the furnace gases.

J. R. C.

14. Comparative Tests of Chemical Glassware. P. H. WALKER and F. W. SMITHER (*J. Ind. Eng. Chem.*, 1917, 9, 1090).—The tests included chemical analysis, resistance to repeated evaporation, to heat, to mechanical shock, and to chemical reagents, determination of coefficient of expansion, refractive index, and condition of strain. The thermal expansion and refractive index results are not given in the present communication.

Seven kinds of glassware were tested, the letters *K*, *M*, *P*, *J*, *N*, *F*, and *L* representing Kavalier, M.E.G. Co., Pyrex, Jena, Nonsol, Fry, and Libbey respectively.

The analyses of the glasses of the seven types of beakers showed:—

TABLE I.

Percentage Composition.

	<i>K</i> .	<i>M</i> .	<i>P</i> .	<i>J</i> .	<i>N</i> .	<i>F</i> .	<i>L</i> .
Al ₂ O ₃	0.14	1.0	2.0	4.2	2.5	2.7	2.1
Fe ₂ O ₃	0.08	0.35	0.25	0.25	0.23	0.22	0.44
ZnO.....	—	5.6	—	10.9	7.8	3.6	—
PbO.....	—	—	—	—	—	—	1.0
MnO.....	0.02	0.02	0.01	0.01	0.01	0.03	0.03
CaO.....	8.7	0.66	0.29	0.63	0.79	2.6	0.42
MgO.....	0.17	4.3	0.06	0.21	3.4	2.6	0.08
Na ₂ O.....	7.1	10.8	4.4	7.5	10.9	9.8	8.2
K ₂ O.....	7.9	0.30	0.20	0.37	0.30	1.5	0.67
SiO ₂	75.9	73.0	80.5	64.7	67.3	68.6	75.9
B ₂ O ₃	—	3.6	11.8	10.9	6.2	8.1	10.8
P ₂ O ₅	0.08	—	—	—	—	—	—
SO ₃	0.20	0.02	—	—	—	—	—
As ₂ O ₅	trace	0.02	0.70	0.14	trace	0.18	0.36
Sb ₂ O ₅	—	0.60	—	—	0.62	—	—
Total ...	100.29	100.27	100.21	99.81	100.05	99.93	100.00

The evaporation test, which was made only on beakers, consisted in repeated evaporation to dryness of sodium chloride solution

with examination for cracks after each evaporation. None of the wares developed cracks after twelve successive evaporations.

Both flasks and beakers were used in all the heat-shock tests. In the first test, the vessels were filled with water at 4° and heated to boiling over the direct flame. All vessels withstood the tests except *K* flasks and *M* beakers. In the second test, vessels containing boiling water were plunged into ice-water. All types withstood this treatment. The other tests and results are shown in Table II.

TABLE II.

Heat and Mechanical Shock Tests.

N refers to number tested; *U*, unaffected; *F*, failed; *b*, broken; *c*, cracked.

(Paraffin wax heated in vessel to temperature indicated and vessel plunged into ice-water.)

Type.	Heated to 150°.						Heated to 200°.					
	Beakers.			Flasks.			Beakers.			Flasks.		
	<i>N</i> .	<i>U</i> .	<i>F</i> .	<i>N</i> .	<i>U</i> .	<i>F</i> .	<i>N</i> .	<i>U</i> .	<i>F</i> .	<i>N</i> .	<i>U</i> .	<i>F</i> .
<i>K</i>	2	1	1c	0	—	—	4	0	4b	0	—	—
<i>M</i>	2	1	1c	4	3	1c	4	0	4b	2	0	2b
<i>P</i>	2	2	0	2	2	0	4	4	0	5	3	2c
<i>J</i>	2	2	0	2	2	0	4	1	3b	4	1	3b
<i>N</i>	2	2	0	2	2	0	4	4	0	4	0	4b
<i>F</i>	4	3	1c	4	3	1c	4	0	4b	4	0	4b
<i>L</i>	4	4c	—	4	4	0	4	4	0	4	0	4b

Drop test (beakers only, 6 of each ware tested).

Type.	No. that broke on drop of						
	5 in.	10 in.	15 in.	20 in.	25 in.	30 in.	45 in.
<i>K</i>	4	2	—	—	—	—	—
<i>M</i>	3	3	—	—	—	—	—
<i>P</i>	—	—	1	—	1	1	—
<i>J</i>	2	3	—	1	—	—	—
<i>N</i>	3	1	2	—	—	—	—
<i>F</i>	1	2	—	2	—	1	—
<i>L</i>	2	1	—	1	—	2	—

Flasks and beakers of 400 c.c. size were used in the above tests. In carrying out drop tests, beakers were dropped bottom downwards on a thick board from heights increased by intervals of 5 inches.

The solubility tests were made by determining the loss in weight of pieces of the wares upon treatment with water and various solutions commonly used. With water, the action on beakers was continued for about seventy-two hours, the water being heated for about twenty-four hours; on flasks the action was continued for seventeen hours, keeping the water boiling during five hours; with mineral acids, solutions containing sodium chloride and sodium nitrate were mixed with a large excess of sulphuric acid, boiled, and heated for an hour after fumes of SO₃ appeared. With sodium and potassium carbonates and hydroxides and sodium

phosphate, $N/2$ solutions were boiled for twenty minutes in the vessels, and in the case of beakers, fresh $N/2$ solutions were subsequently evaporated in the same beakers and the loss again noted. With ammonia, strong ammonia was allowed to stand for twenty-four hours in the vessel, then diluted and boiled for thirty minutes. With ammonium sulphide and chloride, mixtures of $2N$ -salts were allowed to stand in the vessels for twenty-four hours, then boiled for thirty minutes.

The results are summarised in Table III. In this table the numerical exponents indicate the minor differences in resistance, the lowest number being the most resistant.

TABLE III.

General Summary of Tests.

	Water.	Mineral acids.	Carbonated alkalis.	Caustic alkalis.	Ammonia and ammonium salts.	Heat shock.	Mechanical shock.
K ...	Poor	Good	Poor	Good 2	Good 7	Poor	Poor
M ...	Good 3	Good	Good 1	Good 1	Good 1	Poor	Poor
P ...	Good 2	Good	Good 5	Fair	Good 1	Good 1	Good 1
J ...	Good 5	Good	Good 3	Fair	Good 1	Good 4	Fair
N ...	Good 3	Good	Good 1	Fair	Good 1	Good 2	Fair
F ...	Good 5	Good	Good 3	Fair	Good 1	Poor	Good 2
L ...	Good 1	Good	Good 5	Fair	Good 1	Good 2	Good 2

Full details with regard to size of pieces tested, methods, and results are promised later in a publication of the Bureau of Standards, Washington.

J. D. C.

15. Soluble Glass. E. M. CAVEN (*J. Soc. Chem. Ind.*, 1918, 37, 63).—The kinds of soluble glass in use for various purposes have a ratio of silica to soda by weight of at least 2 to 1, and frequently 3 to 1, or even more. In the former case, the product is known technically as “alkaline silicate”; in the latter as “neutral silicate.” Glasses so rich in silica are not readily soluble in water; indeed, even when finely powdered, they dissolve but slowly and imperfectly in boiling water.

Soluble glass is prepared in either of two ways. In the first method, finely divided silica, in the form of infusorial earth, quartz, etc., is heated with caustic soda solution under a steam pressure of 3 or 4 atmospheres. The resulting dilute solution of soluble glass has to be concentrated before it can be put on the market. In the second, sodium carbonate, or salt-cake and coal, is fused with the requisite amount of silica at 1100° , and the glass so obtained is broken mechanically, or else cracked by dropping it whilst molten into water, and is subsequently dissolved in water.

The dissolution of the glass obtained by the second method is an important technical problem. By heating the glass with water at 150° under pressure, a dilute solution can be obtained, but that solution has to be concentrated. The preparation in the solid form of a soda-glass readily soluble in water is very desirable, and

methods for such a preparation have now been discovered. The processes consist in grinding the nearly insoluble glass obtained by fusion, either with water or in the dry state, and suitably heating the product, thoroughly mixed with a small amount of water, until a vitreous solid results, which readily dissolves even in cold water.

The quantity of water employed influences the degree of solution of the fused glass, and that in a manner opposite to what is usual. The author has carried out a series of experiments with fused glass, finely powdered, and his results show that as the amount of water increases from 1 to 13 parts to 1 of glass the amount of glass dissolved in a given time decreases. The soluble variety is a hydrated form of the fused glass, and the following are the conditions for obtaining it:—

(i) The anhydrous glass should be powdered; it should pass through a sieve with 50 meshes to the linear inch in the case of the "neutral" glass, or through a 20-mesh for the "alkaline." The powder should be exposed to the air as little as possible, since it readily absorbs moisture and carbon dioxide.

(ii) Sufficient, but not too much, water must be mixed with the powdered glass; the weight of water should be 25—38 per cent. of the weight of glass.

(iii) The mixture should be heated sufficiently, but not too strongly. The initial temperature should be about 70°, and the final temperature, after about four hours' heating, should not exceed 100°. The product may be ground, and is practically permanent in air.

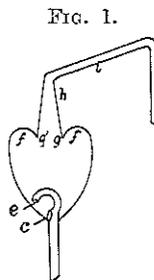
The author discusses the mechanism and chemistry of the dissolution and the probable nature of the solution.

Anhydrous soluble glass is invariably green, due to ferrous silicate. The hydrated product is grey, and much more deeply coloured. The author suggests that this is due to the formation of a ferrosulfuric compound.

J. D. C.

III.—Lamp-worked and General Scientific Apparatus.

16. A Useful Distilling Head. ORLO STEARNS (*J. Ind. Eng. Chem.*, 1917, 9, 972).—This distillation head (Fig. 1) was designed for and found to be very efficient in distilling troublesome fluid extracts. It prevents liquid passing over in the form of minute bubbles, and also stops larger globules which may be formed as the result of bumping. The part of the head that is of most service is the lobes, *f, f'*, in which



bubbles readily break by expansion and condensation. Bubbles often break in passing the circular edge, g , g' , and the large exit is less favourable to the carrying forward of bubbles than a smaller one would be. The opening, e , in the lower part of the bulb is directly above the drainage hole, c , so that in case of bumping, the liquid is turned back on itself, thus tending to force back the ascending liquid. The angle between the tubes h and i should be about 110° .

S. E.

FIG. 2.

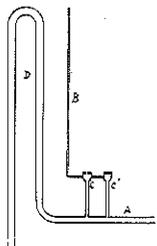


17. A New Form of Safety Pipette. A. S. BEHRMAN (*J. Ind. Eng. Chem.*, 1917, 9, 1047).—In order to avoid the possibility of sucking such substances as acids, alkalies, or poisons into the mouth when filling a pipette, a stiff atomiser bulb is used as a source of suction. A three-way tap is interposed between the bulb and the pipette, so that, when filling, the pipette is in communication with the bulb, and when emptying, the tap is turned so that the pipette is open to the air (Fig. 2).

S. E.

18. A Convenient Automatic Device for Rapidly Washing Pipettes. A. V. FULLER (*J. Ind. Eng. Chem.*, 1917, 9, 1046).—

FIG. 3.



A fairly wide-bore glass tube is bent into the form of a syphon, D (Fig. 3), and the shorter limb is again bent into a horizontal position, A . The horizontal portion is connected to the water supply, and carries pipette holders, c , c' , which have enlargements at their upper ends. Into these enlargements are fitted single-bored rubber bungs, with sheet rubber gate valves on their under side. Leading from the enlargements is a thin "breather" tube, B , to allow the escape of air, which would otherwise be imprisoned in the pipette carriers.

The open ends of the pipettes are placed in the rubber bungs, and the water is turned on. The level of the water rises in the pipettes and in the shorter arm of the syphon until the pipettes are full. The constriction at the top of the pipettes arrests the flow of water in that direction and causes the wide tube to fill up, thus setting the syphon in action and emptying the pipettes. The process repeats itself indefinitely.

S. E.

19. **An Automatic Syphon Starter.** (*English Mechanic*,
 FIG. 4. 1918, 106, 258). A narrow tube, slightly tapered at one

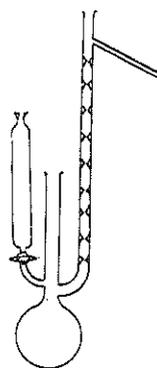


end, is sealed inside one of larger diameter as shown in Fig. 4. The diameter of the outer tube is reduced from the point opposite the free end of the narrow one, in order that it may readily be attached to the syphon. Two small holes are pierced through the wall of the outer tube. When attached to a syphon and immersed, water rushes up the inner tube and flows over into the neck of the outer tube, but instead of falling down this tube, it is caught by air which is being forced from the annular space by water entering slowly through the two small holes. Thus air and water intermixed are forced up the syphon tube and over into the longer arm, so that by the time all the air has been driven out there is sufficient water in the long limb to start the syphon. S. E.

20. **An Efficient Apparatus for Fractional Distillation under Reduced Pressure.** W. A. NOYES and G. S. SKINNER (*J. Amer. Chem. Soc.*, 1917, 39, 2718).—The essential parts of this apparatus are a separating funnel, a Claisen flask, and a fractionating column, sealed together as shown in Fig. 5. The apparatus offers several advantages. It may be used with either large or small fractions of material by regulating the flow from the funnel, and successive fractions can be introduced without losing the vacuum.

In making the fractionating column, the indentations should almost meet near the middle of the tube, and each successive pair should be at right angles to the preceding ones. S. E.

FIG. 5



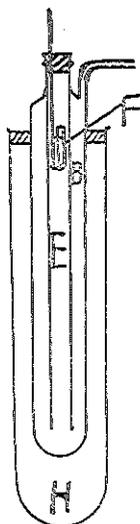
21. **An Improved Form of Pyknometer.** MARKS NEIDLE (*J. Amer. Chem. Soc.*, 1917, 39, 2387).—In order to allow for the expansion of liquids when determinations of their density are being made at low temperatures, caps are ground on to the side arms. The caps are made rather large, and are constructed so that the ends of the side arms just fail to reach their interior ends. The liquid, on expanding, touches the inside of the cap and runs down the greater incline rather than back along the outside of the side arm. S. E.

22. **Improved Victor Meyer Vapour Density Apparatus.** D. A. MACINNES and R. G. KREILING (*J. Amer. Chem. Soc.*, 1917, 39, 2350).—This modified Victor Meyer apparatus (Fig. 6) is more compact than the original, and inequalities of temperature along the vaporisation tube are removed.

The liquid to be vaporised is sealed up in a small bulb (*F*), which is attached to a breaking arrangement by a rubber band. On breaking the capillary stem of the bulb, the liquid immediately vaporises and spreads out into the inner tube, *E*, and forces air from the outer tube, *B*, through the capillary to the gas burette. The constant temperature jacket is provided by a boiling tube, *H*, and it is necessary to have its temperature at least 50° above the boiling point of the liquid under investigation.

S. E.

FIG. 6.



23. A New Method of Sealing Electrical Conductors through Glass. M. J. ANDERSON (*Brit. Assn. Reports*, 1913, p. 405).—The method consists essentially in fusing the metal and glass together in the usual way, and then immersing the seal, after it has cooled to about a red heat, in a bath of oil or fat. Each immersion lasts about two or three seconds, and each successive time the seal is immersed a little further until it is completely cooled. By this means a copper tube capable of carrying 100 amperes was sealed through German glass. Platinum wires were sealed through Jena glass in mercury vapour lamps, and the seals were found to be air-tight after a period of more than eight months, although they had been subjected to the heat of the lamps when burning. By making a seal in this way, it is claimed that copper wires can be used throughout in the making of electric lamps.

S. E.

IV.—Decorated Glass.

24. On the Relation between Physical Properties and Chemical Composition of Glass. VII. Etch Figures. EDWIN WARD TILLOTSON, JR. (*J. Ind. Eng. Chem.*, 1917, 9, 937).—When glass is exposed to the vapour of hydrofluoric acid, or dipped into a solution of hydrofluoric acid, with or without the addition of soluble fluorides, the surface is etched unevenly, there being produced “etch figures” of varying forms and more or less crystalline in appearance.

There are two well-defined opinions regarding the cause of the mat-etch: the one supposes “pre-existing” crystals within the glass, whilst the other is based on the protective action of insoluble fluorides and fluosilicates formed during the etching process. A series of experiments was accordingly carried out in the endeavour to throw more light on this subject, as it seemed distinctly worth

while that this question should be settled, not only because of its importance in the practical etching of glass, but also for whatever bearing it might have on the theory of the molecular structure of glass. The materials used were hydrofluoric acid containing about 45 per cent. HF and ammonium fluoride.

Pure hydrofluoric acid dissolves the glass, in general, evenly, and with the production of only occasional etch figures. When, however, the amount of ammonium fluoride is increased, the etch figures become more and more definite in shape, which is not materially altered by increasing the amount of ammonium fluoride beyond the molecular ratio $\text{NH}_4\text{F}, 2\text{HF}$. In general, too, the more concentrated the etching solution the smaller will be the etch figures. Also it was observed that all solutions which produced a mat-etch, when diluted produced etch figures resembling true crystals. Hence these facts seem to show, broadly, that the form of the etch figures is independent of the chemical composition of the glass, and is determined by the composition of the etching solution. This generalisation supports the protective-coating theory rather than the pre-existing crystal hypothesis. The final explanation of the formation of these figures was secured as a result of watching with the microscope the etching process, from which it was gathered that the etch figure is produced by the protective action of crystals which are formed as the etching proceeds.

Hence the etch figures result from two simultaneous actions—the solution of the glass and the growth of the crystal which is in mechanical contact with the glass surface. It is to be expected that the presence of other metals which form insoluble fluosilicates will produce characteristic etch figures in accordance with their crystalline habit. This can be illustrated in the case of potash-lead glass, the etch figures being decidedly characteristic of potassium; and, so far as the writer has observed, they are always produced by an etching solution which contains potassium, irrespective of the composition of the glass. Borosilicate laboratory glasses also produce some characteristic figures.

This theory of etching also indicates that if the etching solution contains no substance which produces insoluble fluosilicates or fluorides, the glass should be dissolved evenly, as with hydrofluoric acid alone, and without characteristic etch figures. It is therefore apparent that the glass is dissolved evenly and as a whole by the etching solution, whatever the composition of the solution may be, and that the mattness and etch figures result from a secondary protective action of whatever insoluble materials are formed in contact with the glass surface. The character of the etch figures will be determined by the most insoluble substance deposited, and this perhaps explains the results obtained with acid ammonium fluoride and the potash glass, and also with the borosilicate laboratory ware.

From the foregoing it is concluded that:—

- (1) All glasses dissolve evenly in acid fluoride solutions.
- (2) Matt etches and etch figures are obtained only when insoluble substances are formed in contact with the glass surface

and when the solution of the glass in such local areas is thereby prevented.

(3) When the etching solution is acid ammonium fluoride, crystals of ammonium fluosilicate form the protecting material.

(4) The etch figures result from a solution of the glass and the growth of crystals, deposited from the solution, in contact with the glass surface. Both reactions take place simultaneously.

C. M. M.

25. The Deposition of Silver Films on Glass. ALEXANDER SILVERMAN and RAYMOND M. HOWE (*J. Ind. Eng. Chem.*, 1917, 9, 1032).—The purpose of this investigation was to produce the best mirrors with the highest percentage deposition, and at room temperature if possible. In the first place, the mirrors were studied from a qualitative point of view, and then the most satisfactory processes were examined quantitatively. Methods involving the use of sugars, tartrates, and formaldehyde as reducing agents were included.

The following general conclusions were drawn. In hot processes, that is, 70° to 85°, cane-sugar is the most satisfactory reducing agent. Other sugars give good results, but no better than cane-sugar. The tartrates are not as satisfactory as the sugars.

A rapid cold process was developed, methyl alcohol being used as a control agent. A batch is required of the following proportions:—20 c.c. of 0.2 molecular silver nitrate solution mixed with 0.5 c.c. of 80 per cent. methyl alcohol. To this 0.5 c.c. of 40 per cent. formaldehyde is added, and the whole mixed thoroughly.

A slow cold process was developed, based upon the following principles:—(1) Low concentration of the reducing agent, namely, formaldehyde, gives the best results. This helps to lengthen the time of reaction. (2) Low concentration of silver nitrate gives high deposition percentages. (3) Sugar added to the solution in sufficient amounts controls the action of the formaldehyde in such a way as to produce even mirrors. It also lengthens the time of action. (4) Alcohol added to the solution results in a high deposition efficiency.

By grouping these principles, the following batch was devised:—16.5 c.c. of 0.037 molecular silver nitrate solution, 1.0 c.c. of 1.000 molecular cane-sugar solution, 0.5 c.c. of 80 per cent. methyl alcohol, and 2.0 c.c. of 0.8 per cent. formaldehyde solution.

After forty minutes, more than 20 per cent. of the total silver is deposited, and if left longer a heavier mirror results. The cost of materials is not more than 1d. per square foot. The mirror is firmly attached to the glass, for two reasons: because the temperature of the glass and solution is the same, therefore the deposition is more uniform than that which occurs at higher and more difficultly controllable temperatures; also, since the deposition takes place at room temperature, differences in coefficient of expansion do not cause the newly-formed mirror to be loosened from the glass, as may be the case where hot processes are employed.

C. M. M.

26. "Red Etching" of Glass Articles by means of Copper Compounds. L. SPRINGER (*Sprechsaal*, 1917, 50, 95, 104, 111).—An extension of previous work by the same author (*Sprechsaal*, 1916, 49, 50; this Journal, 1917, 1, A., 18). In the present paper, the author deals with the influence of the composition of the glass on the successful production of the colour.

The method of procedure adopted was as follows. Suitable glass vessels were painted over with a paste consisting in the majority of cases of 100 parts of calcined "yellow earth" (ochre) and 200 parts of crystallised copper sulphate, the latter being dissolved in water, the solution added to the earth, the resulting paste evaporated to dryness, and then heated to 300°, and finely ground. The vessels were then heated in a muffle oven to a temperature of about 600°. In successful cases, this caused the glasses to acquire a yellowish-green colour. The paste was then washed off and the glasses heated in a reducing atmosphere, when they acquired a black lustre. Finally, the glasses were re-heated in an oxidising atmosphere to develop the desired ruby tint.

The author found that the most suitable glasses for developing the ruby colour in this manner were Nos. 1 and 3, having the following composition respectively:

	No. 1.	No. 3.
Silica	72.0	73.5
Lime	9.0	6.5
Soda.....	5.5	2.0
Potash.....	12.0	18.0
Alumina and iron oxide—not determined.		

These glasses were obtained by use of the following batch mixtures:—

No. 1.—Sand, 100; limespar, 22; soda-ash, 13; and potash, 24.

No. 3.—Sand, 100; limespar, 16; potash, 36; soda-ash, 3.5.

Glass No. 2, having the percentage composition: silica, 78; lime, 6; soda, 16, gave very poor results, a certain amount of "red etching" being produced, but this only at temperatures which caused deformation of the glasses. Whether the comparative failure is due to the glass being too soft or soda-glasses in general being unsuitable to this method of colouring is not made clear.

Increasing the amount of copper in the paste has not a corresponding effect on the depth of tint produced, but the latter may be intensified by repeating the treatment.

The author corrects a common error in respect to the "reduction" or second firing. The black surface produced is usually attributed to a surface deposit of carbon which is burnt off in the third firing. (This statement is made by the author himself in his earlier paper.) It has been found, however, that the black film is really an "etching" effect, the black colour being supposedly due to metallic copper, which is oxidised to cuprous oxide in the third firing.

J. H. D.

27. Etching Solutions without Hydrofluoric Acid. (*Sprechsaal*, 1917, 50, 251).—Two mixtures are recommended.

They are rather more expensive than similar ones containing free hydrofluoric acid, but avoid much of the danger met with in handling that substance. They are as follows:—

I.		II.	
Distilled water.....	1000	Distilled water.....	500
Potassium fluoride.....	250	Ammonium fluoride.....	500
Hydrochloric acid.....	250	Ammonium sulphate ...	50
Potassium sulphate ...	140	Sulphuric acid.....	100

The components are mixed together in a leaden vessel and heated on a water-bath with constant stirring until dissolved. J. H. D.

V.—Optics and Optical Instruments.

28. Refraction through a Prism. W. E. WILLIAMS (*Optician*, 1918, 54, 227).—A geometrical construction is set out for finding the angle of incidence required to obtain a given deviation in a prism of known angle and refractive index. The converse problem, of finding the deviation with a known angle of incidence, is first considered, and Reusch's construction given for this. To reverse this construction, and to find the angle of incidence by trial of several such angles would be tedious, and analytical solution yields a biquadratic which has to be solved for each particular case. Therefore a graphical solution is described. Having obtained the angle of incidence, the tilt which must be given to the prism from its minimum deviation position in order that the required deviation may result can be calculated. J. R. C.

29. Refraction through a Prism. T. CHAUNDY (*Optician*, 1918, 54, 249).—The author of this paper points out that there is an analytical solution of the problem which does not involve the solution of a biquadratic. It is that of the geometrical processes of Williams's method (preceding abstract). J. R. C.

30. Light Filters for Eye Protection. L. C. MARTIN (*Trans. Opt Soc.*, 1917, 18, 73).—A description of experiments conducted with the view of finding the best filter for absorbing heat and light rays, which are harmful to the eyes. The harmful effect is probably due to the absorption of the rays by the different media of which the eye is composed. E. K. Martin has shown that the cornea absorbs wave-lengths less than 0.295μ , that the crystalline lens begins absorbing at 0.38μ and absorption is complete at 0.35μ , and that the vitreous has an absorption band between 0.25μ and 0.28μ , but is otherwise transparent.

The author states that ultra-violet radiation of low intensity produces no permanent harm, but that corneal opacity results from great intensity. Excessive light in the visible region produces

"glare," and may destroy the nervous structures. Another sort of glare arises from efforts to focus a moving object or when the eye is observing a small object. For the best vision, a fairly even illumination of the retina is desirable. Excessive exposure to heat rays causes cataract, so a filter which cuts off red as well as violet light without distorting the colour is wanted. As the eye is not achromatic, such a filter would improve definition. It is shown that the strain when using telescopic systems is seldom due to great intensity, and three possible causes are suggested, namely, uneven illumination of the field, bad definition, and vibration of the image.

For examining the effect of various filters on ultra-violet light, a quartz spectrograph was used. Half the slit was illuminated by light which had passed through a filter and the other half by the full radiation from the same source. The exposures could be varied, by means of rotating sectors placed in the paths of the beams, so that equal intensities were obtained on the plate for a measurable wave-length. From this, the fraction absorbed at any wave-length could be obtained. It was found that the thickness of the glass, the intensity of the source, and the length of the exposure all affect the apparent limit of transmission.

To compare the intensities transmitted in the visible spectrum, Abney's method was used. The light, after passing through a spectroscope in which a slit is substituted for the eyepiece, is divided into two beams, one of which passes through the specimen under test. Both beams are made to throw the shadow of a rod on to a white screen, and the intensities of the shadows are equalised by means of rotating sectors.

The apparatus used for the infra-red was essentially a mirror spectrometer with a rock salt prism. The rays were received on a slit, immediately behind which was a thermopile. The apparatus was calibrated so that the wave-length falling on the slit was known.

The theory of absorption is briefly discussed, and it is shown how the results obtained for one thickness of glass can be transformed for other thicknesses. Eight kinds of glasses were examined, and the results embodied in numerous tables. Diagrams showing the variation of percentage transmission with wave-length for each specimen are also given. It is pointed out that metallic films on glass provide useful filters, but the difficulty of making them is against their use. They must be well protected when made. A long list of papers by other investigators is appended.

J. R. C.

31. On the Enfeeblement of a Normally Incident Light Wave produced by a System of Parallel Glass Plates. H. LUNELAND (*Phys. Zeitsch.*, 1909, 10, 222).—When light is reflected or refracted at the surface of a transparent medium, the decrease in the amplitude of vibration of the incident wave, and therefore of the intensity of the light, is known, by the Fresnel-Neumann

formula, to depend on the refractive index. With a single parallel plate an infinite series of images is formed, and the problem is complicated when a number of plates are used. The author has obtained several formulæ for the intensity of the transmitted light, and has tested them by photometric observations. A Nernst lamp was used as the source of light, and the transmitted intensity measured through from six to sixteen plates, both when they were packed close and when separated. The observed ratios of the intensities transmitted in close packing and separation agree with the calculated values. J. R. C.

32. On the Transmission of Ultra-violet Light through Glass. C. FRITSCH (*Phys. Zeitsch.*, 1907, 8, 518).—A glass which is both durable and transparent to the ultra-violet is difficult to obtain. The author gives a batch mixture for making such a glass. Six grams of commercial calcium fluoride and 14 grams of boric oxide are powdered, mixed, and melted in a platinum crucible. The mixture is then poured on to a cold platinum plate and cooled slowly. The glass so obtained is transparent so far as the Al line $\lambda = 1,852$ A.U. The addition of alumina did not affect the absorption. Thick pieces 3 or 4 cm. in diameter, with no scratches, have been obtained by this method. J. R. C.

33. A Simple Proof of the Expression for the Focal Power of a Thick Lens. C. COCHRANE (*Optician*, 1917, 54, 71).—A proof of the expression is obtained geometrically by considering the path of a single ray. The method is the same as that employed for a thin lens. J. R. C.

34. The Power of a Lens System. T. CHAUNDY (*Optician*, 1917, 54, 113).—This paper gives a mnemonic way of writing Cotes's formula, expressing the power of a system of lenses in terms of the powers of the surfaces and of the thicknesses and separations of the lenses. The method is very easily remembered. J. R. C.

35. Another Mnemonic. T. CHAUNDY (*Optician*, 1917, 54, 205).—A method of writing down the ratio of the separation of unit planes of a symmetrical optical system to its focal length. The idea is similar to that employed in a previous paper for writing the power of the system. From these two formulæ the actual separation of the unit planes can be determined. J. R. C.

36. Note on Accuracy of Observation and Precision in Measurement. G. H. CARSE (*Trans. Opt. Soc.*, 1917, 18, 114).—Errors are divided into systematic and accidental errors. The first class can be corrected and allowed for, but those of the second class are of varying magnitude and with a random distribution of signs. The probable value of a quantity repeatedly measured directly is the mean of the separate measurements. The author derives ex-

pressions for the possible accidental error of a quantity indirectly ascertained by measuring two other quantities. If, in general, $a = x^p y^q$, a being the constant obtained by calculation, x and y the magnitudes determined, and p and q constants, then, if λ , α , and β are the possible errors in these quantities, it is shown that $\frac{\lambda}{a} = p \frac{\alpha}{x} + q \frac{\beta}{y}$, the signs being chosen to make the resultant error a maximum.

J. R. C.

37. Polish. LORD RAYLEIGH (*Trans. Opt. Soc.*, 1917, 19, 38).—A reprint of a lecture given at the Royal Institution in 1901.

When grinding a glass surface, the particles of emery appear to act by breaking off small fragments of the surface. To save time, it is desirable to carry this process as far as possible, using, towards the finish, only the finest emery. The fineness necessary in order that the surface may reflect and refract without diffusion, that is, in order that it may appear "polished," depends on the wave-length of the light and upon the angle of incidence, a regularly corrugated surface behaving as if plane if the wave-length of the corrugations is less than that of the incident light. Finely-ground surfaces are still too coarse for perpendicular specular reflection of the longest visible light waves. Herschel appeared to deduce from this that polishing is merely a continuation of the grinding process, but the balance of evidence points in the opposite direction. The same powder, *e.g.*, emery, may be used in both cases, but, when grinding, it is backed by a hard surface, whilst in polishing it is embedded in a yielding substance, such as pitch. This precludes more than a moderate pressure, and it is probable that the material is worn away almost molecularly. Under the microscope, it is seen that little facets are formed on the more prominent eminences, and as the polishing proceeds these increase in number and size till they occupy much the larger part of the area. The completion of the process consists in the extension of these facets till there are no pits left. The microscope also shows that their polish does not alter in quality as the operation proceeds. The thickness of material removed in polish varies up to about ten wave-lengths of mean light.

Hydrofluoric acid has been employed to correct ascertained errors in optical surfaces. The action of this acid, if weak, is extremely regular. It should be kept in constant motion by a rocking arrangement. An explanation of the action of the acid on a finely-ground glass surface is put forward.

J. R. C.

38. The Grading of Carborundum for Optical Purposes. J. W. FRENCH (*Trans. Opt. Soc.*, 1917, 19, 2).—Reasons are given for the adoption of carborundum as the sole abrasive in optical work, the author showing that it is more economical than emery. The difficulty involved in its use arises in separating the finer grades for smoothing, preparatory to polishing, and it is this question which is considered.

The coarse, commercial carborundum is broken down in the "roughing" mills of the optical shop, and the resulting sludge is not suitable for grading by a current of air. Elutriation is therefore employed. The problem is made more complex by the deviations of the particles from Stokes's law. The causes of these deviations are fully discussed. On the basis of Stokes's formula, the plan of the grading tank should be triangular, but, experimentally, it has been found that it should be parallel-sided. Initial irregularities in the force of the stream may be destroyed by making the water move down and up between vertical baffles, and then pass onwards through vertical gauze screens, the function of which is to destroy eddy currents. At the entrance to each tank should be screens to retain any particles that should not have passed the preceding tank. For the finer grades it is necessary to depend on silk sieves, which are difficult to obtain. The irregularities of wire sieves are considered at length. A typical grading tank is described in detail.

The application of centrifugal machinery to the grading of abrasives has been proposed, and a centrifugal separator is described. The author suggests that electro-osmose methods, when applied to carborundum, may simplify the final settling process.

In a lengthy discussion which followed the paper, Mr. P. F. Everitt suggested another kind of settling tank in which the finer grades were removed first. Dr. W. Rosenhain gave reasons for the deviations from Stokes's law, and referred to a method of grading by suspending the particles in ammoniacal water and precipitating them by the addition of nitric acid when required. Dr. R. Clay considered that all the methods of separation described by the author of the paper were complicated by the motions superimposed on the particles by the stream-line flow of the liquid. He also described another type of centrifugal separator. J. R. C.

VI. Fuels, Refractories, and Furnaces.

39. Recent Developments in the Industrial Application of Town's Gas. C. M. WALTER (*J. Soc. Chem. Ind.*, 1917, 36, 769).

—The degree to which town gas will ultimately replace solid fuel will depend to a great extent on the increased heating efficiency to be obtained by its use. That the heating efficiency of the gas furnace will be considerably increased is certain, as up to the present little has been done in the way of conserving the heat carried away in the waste gases by the employment of regenerative systems.

The advantages obtained by the use of town gas, due to cleanliness, convenience, simplicity, and ease of temperature control, must weigh greatly in its favour in the case of many manufacturing

processes. In some instances there is no doubt that town gas can compete with solid fuel on a fuel cost basis alone.

The author referred to an installation of gas-heated lehrs for the annealing of glass. The installation consisted of two annealing furnaces, each approximately 74 feet long, 5 feet 6 inches wide, and 2 feet 6 inches in height to centre of arch, the combustion chambers extending for a length of 20 feet and arranged beneath the bed with suitable regenerative settings for the pre-heating of the air. Gas was supplied at ordinary town pressure through ordinary atmospheric burners, the secondary air being pre-heated prior to its entrance to the combustion chambers.

Tests showed that to maintain a temperature of about 550° when under load, a gas consumption of approximately 750 cubic feet per hour was required, corresponding with an efficiency of just over 30 per cent., whereas in the case of a similar furnace direct-fired by coal, the fuel consumption approximated to 1 cwt. of coal per hour, corresponding with an efficiency of 8.5 per cent.; the fuel costs amounted to 11.25 pence per hour in the case of the gas-heated furnace, as compared with 10.8 pence per hour in the case of the coal-fired furnace, the cost of handling the fuel not being included in the latter case.

At the present time, many thousands of brass, gun-metal, and aluminium castings are being produced in furnaces heated by town gas; also in many parts of the country cast-iron is being melted in pots of 60 lb. to 120 lb. capacity.

The fuel cost is higher than when melting by coke, but the extra cost is justified by the superior quality of work which can be obtained.

Increased efficiency in the annealing, carburising, hardening, and tempering of iron, steel, and brass is being obtained by the use of town gas.

A. M. J.

40. Industrial Fuel from Gas Works. E. W. SMITH (*J. Soc. Chem. Ind.*, 1917, **36**, 758).—The paper strongly advocates the cessation of the use of coal for all heating purposes, and also notes that there is really no satisfactory reason why the gas industry should merely distil coal for gas, leaving the coking industry to produce coke. At the Saltley Gas Works 66 ovens of the Kopper's type produce excellent blast-furnace coke. The whole of the coke is available for sale, because the ovens are heated by means of external producers in which inferior cheap fuel is used. The coke is screened and the various portions sold for different purposes. The coke dust, for which there is little sale, is being converted, after admixture with 70 per cent. slack, into producer gas for heating the ovens, and about 45 lb. of sulphate of ammonia per ton is recovered as a by-product per ton of dust.

During the coking, about 10 gallons of tar are obtained from each ton of coal. The composition of the tar varies with the carbonising installation used and the temperature maintained.

The average quantity of creosote present in the tar may be taken as 30 per cent. Used under boilers, 1 lb. of creosote will evaporate

11.24 lb. of water, a result which is nearly twice as good as when coal is used.

Gas, however, is the most important type of fuel produced in the gas works. Now that well over 90 per cent. of the gas is used for heating purposes, including the incandescent mantle, gas is more frequently standardised on calorific value than on illuminating power.

The standard minimum quality of gas which most undertakings are adopting by permission of the Government departments concerned is 500 B.Th.U. gross.

If 500 gross is the standard agreed upon, then, unless blue water gas of good quality be used for dilution, the inert gases are bound to be high.

The inert gases should, however, be kept low and uniform, for there is really no sense in distributing nitrogen and other incombustible substances.

A. M. J.

41. The Calorific Value of Industrial Gaseous Fuel. W. J. PICKERING (*J. Soc. Chem. Ind.*, 1917, 36, 762).—For industrial purposes, "total heating value" of a gas is defined as "the number of British thermal units produced by the combustion, at constant pressure, of the amount of the gas which would occupy a volume of one cubic foot at a temperature of 60° F. if saturated with water vapour, and under a pressure equivalent to that of 30 inches of mercury at 32° F., and under standard gravity, with air at the same temperature and pressure as the gas, when the products of combustion are cooled to the initial temperature of gas and air, and when the water formed by combustion is condensed to the liquid state."

Up to the commencement of the present war, the Junker's calorimeter had been adopted for many years at Birmingham as the best instrument for technical work. Since 1914, a calorimeter of similar pattern, but with alteration of several points in the design, tending both to greater accuracy of result and longer life of the instrument, has been constructed.

A detailed description of the instrument is given. It consists essentially of a chimney in which the gas is burnt centrally in a special burner, together with a "flow" calorimeter provided with inlet and outlet thermometers which give the temperature to the nearest 0.01° and have the advantage of being at the same level.

A junior assistant can carry out a test in 10 minutes with a margin of error of 1 per cent.

A. M. J.

42. The Classification of Refractory Materials. E. P. PAGE (*Trans. Faraday Soc.*, 1917, 12, 173).—Refractory materials are usually divided into three classes, namely, acidic, basic, and neutral, according to their chemical composition and their behaviour towards each other or towards compounds brought into contact with them.

Materials belonging to the "acid" class are always used where it is a case of refractoriness towards heat, because they are widely

distributed, comparatively low in first cost, and lend themselves readily to adaptation for particular purposes.

Suitable "basic" and "neutral" materials, on the other hand, are not so widely distributed, and possess in many instances inherent properties which render them difficult of application. Purely basic or purely acid conditions seldom exist, so that a successful issue is generally the result of compromise.

Acid materials include siliceous materials containing more than 80 per cent. SiO_2 , such as quartz, quartzites, sandstones and sand, and clays. The purest forms of silica are used for quartz glass, the less pure for silica bricks.

In a clay, refractoriness generally varies directly with the content of alumina. The most refractory clay corresponds with the formula $\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$. Clays corresponding with this composition are scarce, the most abundant being the china clays. There is another class of refractory clays, generally known as "ball" clays, which are more silicious than china clay, and vary in refractoriness accordingly. Magnesite, dolomite, and alumina are basic materials. Magnesite is perhaps the most useful, but possesses the disadvantage of being a good conductor of heat.

Both magnesite and dolomite are refractory towards basic slags and metallic oxides and can be made into bricks.

Alumina is a valuable refractory material, but the price at which it is obtainable is against any very extensive use. For special purposes it can be mixed with plastic clays to raise their refractoriness.

Chrome, bauxite, carbon, and zirconia are examples of neutral refractory materials.

Ground chrome can be used as a mortar with dolomite, and electric furnace operators use it extensively.

Bauxite, a naturally occurring hydrate of alumina, requires shrinkage at a very high temperature.

Carbon cannot be used under oxidising conditions. A. M. J.

43. The Examination of the Texture of Unfired Refractories. R. LESSING (*Trans. Faraday Soc.*, 1917, 12, 152).—Whilst a good deal of information on the rational composition and the mode of bondage of finished refractories may be gained by cutting and grinding sections of the fired goods, the quantitative ratio of such main constituents as "grog" and binding clay can only be estimated very roughly. The importance of the relation of "grog," that is, the skeleton, to "green" clay or the binding matrix warrants a method for the quantitative separation of the materials before they undergo the final firing. The method consists of a simple process of elutriation, by which the true clay substance of the "green" clay is removed by a gentle current of water, whilst the "grog" and heavy, coarse-grained residue is left behind.

The resultant products of clay and residue are dried and the residue screened. The fractions not passing through a twenty-mesh sieve contain particles which can be separated by hand-picking

into such constituents as "grog," uncrushed "green" clay, shale, or coal. The "grog" itself may be further separated into broken brick, saggar, virgin clay, or other natural rock.

The fractions, as well as the dried clay, are weighed and their percentage of the total ascertained. A small portion of the sample is submitted to a moisture test, and all the figures obtained reduced to the "dry" basis.

Where required, each constituent may be submitted to chemical analysis or physical tests.

Results obtained from four typical samples are recorded below.

Grade.	1.	2.	3.	4.	
Plus $\frac{1}{2}$ inch	—	—	—	21.4	per cent.
$\frac{1}{2}$ -inch— $\frac{3}{4}$ -inch	—	—	—	17.0	"
$\frac{3}{4}$ -inch—10 mesh	8.8	9.0	15.6	10.0	"
10—20 mesh	19.9	17.5	10.6	4.4	"
20—30 mesh	10.6	7.0	3.6	1.9	"
30—60 mesh	15.8	11.0	4.4	3.8	"
60—90 mesh	8.8	7.0	3.4	3.7	"
Minus 90 mesh	7.7	4.0	1.7	3.8	"
Fine clay.....	28.4	44.5	60.7	34.0	"
	100.0	100.0	100.0	100.0	per cent.

Sample 1 was a gas retort mixture from Stourbridge district before adoption of Gas Engineers' standard specification.

Sample 2 was a gas retort mixture from Glenboig district before adoption of standard specification.

Sample 3 was a gas retort mixture from Stourbridge district after adoption of standard specification.

Sample 4 was a gas retort mixture from a German firebrick works.

The outstanding feature of the results obtained from 1 and 2 is the small percentage of useful "grog." This was largely owing to the fact that the "grog" and "green" clay were ground together—much of the "grog" was crushed so fine that it did not fulfil its proper function of supplying a rigid skeleton, whilst the more elastic clay escaped the grinding action, remaining in granules, which not only had no binding effect, but formed a skeleton which was not rigid and caused considerable shrinkage on drying.

To comply with the requirements of the standard specification, it is necessary to grind "grog" and "green" clay separately.

The tests on the German gas retort mixture show that it is possible, with a proper preliminary treatment, to add a very much larger proportion of "grog" than has been attempted by British makers, and at the same time to increase considerably the size of the particles.

A. M. J.

44. The Application of Petrographic Methods to the Study of Refractory Materials. W. G. FEARNSIDES (*Trans. Faraday Soc.*, 1917, 12, 148).—The study of materials by the microscope possesses great possibilities for obtaining real information about the composition and texture of manufactured refractory materials, as well as of natural rock substances.

Most bricks may be regarded as consisting of two grades of materials, the one, which we may speak of as the *plums*, enclosed in the other, the *porridge*.

The refractory properties of most of the coarse-textured materials which form the plums are fairly well understood, but in the porridge there are mixtures of many chemically different materials, and in firing chemical reactions are prone to occur which make the refractory properties of the fired product totally different from those of any of its constituents.

The great use of the microscope is to note what has happened at boundaries where, in the porridge, distinct chemical entities meet.

To study the materials under the microscope, thin, transparent slices need to be prepared. The preparation of such specimens is one of the "key industries" for which, prior to the war, we depended on another country; from the national point of view, it is urgent that the matter be taken in hand by some business firm.

Rubbed-down specimens of refractory bricks made from basic materials in which high refractive index is a characteristic property of the mineral constituents (for example, magnesite, chromite, bauxite, zirconia) furnish a means of judging the measure of success which has attended the making of the brick, and also with experience how particular batches of brick will behave when built into the walls or roof of a furnace.

In dealing with acid materials, the technique of thin slice-making is more difficult than with the basic; the materials are more tender. Minerals containing a high percentage of silica have comparatively low refractive indices, and without a great deal of experience it is difficult to be certain of even such important differences as those between quartz and felspar, or between quartz and the polymorphic forms of silica, tridymite, and cristobalite.

There are, however, other methods of dealing with these low refractive index materials. By observations upon the crushed material with the refractometer one learns to distinguish between quartz and tridymite, and by an inspection of the powder immersed in various liquids one gains an excellent and correct idea of the amount of heat treatment that the brick has received.

In newly-made firebricks or those which have not been long fired the texture is so fine-grained that in slices 1/1,000 inch thick the mineral constituents are in such tiny crystals that they appear as felted fibres, which generally interfere one with another.

From furnaces which are falling to pieces after a long and very successful life, recrystallised, rock-forming materials, which under the microscope are the most beautiful of objects, may frequently be obtained.

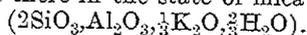
45. The Use of the Microscope in the Study of Refractory Materials. CECIL H. DESCH (*Trans. Faraday Soc.*, 1917, 12, 151).—Since the greatest difficulties were encountered in grinding sections of slags, cement clinker, and similar substances sufficiently

thin to bear examination by the usual optical methods used for transmitted light, the author has adopted the method of grinding one surface only of the specimen in the usual manner for petrological work, and of examining it in the etched or unetched condition by means of a metallographic microscope with a vertical illumination. The low reflecting-power of firebrick, slag, and other similar substances presents a certain difficulty, as the surface is apt to be obscured by diffused light. This can be overcome by regulating the lenses and diaphragms of the optical bench. In this way, sharp photographs of a eutectic structure in Portland cement clinker have been obtained. This structure is quite invisible in thin sections of the same clinker.

The different constituents can be distinguished by etching with dilute hydrofluoric acid or other reagent. A. M. J.

46. Notes on the Composition of Clay and on Silica Bricks.

H. LE CHATELIER (*Trans. Faraday Soc.*, 1917, 12, 135).—The statement that clay is a mixture of true clay, quartz, and felspar is not correct as to felspar, which is practically never present in clays. All potash is there in the state of mica



This is confirmed by the fact that nearly all the potash is soluble in sulphuric acid, which would not be the case with potash originating from felspar.

The conclusion that a chemical analysis cannot enable one to foresee the fusibility of a clay is only partially true.

Felspar, for example, only begins to soften between 1100° and 1200°. If a mixture of silica, alumina, and carbonate of soda, in the same proportions as in felspar, be heated, semi-fusion will be noticed at about 800°, the melting point of carbonate of soda. But the soda will gradually combine with the silica and alumina, and in a short time the mixture will assume the properties of true felspar.

So, on rapidly heating a clay, there may be a momentary partial fusion (say of the alkalis, which are always present in clay), which would cease when the combinations had reached the stable state. Such fusions are seen in the first burning of bricks, but not in their subsequent use. Silica melts at 1800°, alumina at 2050°. The fusibility of silica is diminished by additions of alumina, the decrease being gradual from the mixture $15\text{SiO}_3, \text{Al}_2\text{O}_3$, which melts at 1650°, to pure alumina at 2050°. Pure kaolin melts at 1800°, like silica, and therefore is not the most refractory compound of silica and alumina.

When silica bricks are used for some time in steel furnaces, the brick, as shown by photographs with polarised light, is transformed into tridymite, a variety of silica with a density 2.28.

Silica bricks burnt rapidly in a laboratory at a very high temperature show crystals of cristobalite, a variety of silica with a low density, which gradually changes into tridymite.

A. M. J.

47. Silica as a Refractory Material. COSMO JOHNS (*Trans. Faraday Soc.*, 1917, 12, 165).—The paper deals with the use of silica as a refractory material used in the construction of furnaces for the manufacture of steel.

One point raised is that a brick rendered darker, denser, more refractory, and more able to withstand temperature variations without fracture by exposure to the furnace atmosphere for a long period, contains 15 per cent. by weight of magnetic oxide of iron.

That the presence of such a quantity of magnetite should be accompanied by improved quality in the brick is noteworthy. It is rare that quartzites used for silica brick manufacture contain much oxide of iron.

In Japan, a ferruginous quartzite containing 4.5 per cent. of ferric oxide has been tried, and the resulting brick found to be rather more refractory than the usual type.

The result of adding magnetic oxide of iron to the orthodox brick mixture would not be strictly comparable, for the oxide would only occur in the matrix, while in the Japanese experiment it was disseminated through the quartzite.

Bricks containing oxide of iron should be burnt in an oxidising atmosphere to avoid the formation of the fusible ferrous silicate. It is only in the portion of the furnace exposed to an oxidising atmosphere that the presence of magnetite in the "seasoned" brick is not only not detrimental, but is advantageous. In the gas uptakes, where during alternate reversals the incoming gaseous fuel at a high temperature is in contact with the brick, corrosion due to the formation of ferrous silicate takes place.

Fine-textured bricks seem to be the most rapidly attacked, and the larger fragments of silica are the last to yield.

In general, the variability in the refractory properties of silica bricks is not altogether due to differences in the composition of the raw material used or to their proportions, but the size of the quartz fragments and the nature of the heat treatment are controlling factors.

A. M. J.

48. The Thermal Conductivity of Materials employed in Furnace Construction. EZER GRIFFITHS (*Trans. Faraday Soc.*, 1917, 12, 193).—Materials employed for the thermal insulation of the refractory lining of a furnace so as to conserve the heat as much as possible are of prime importance both from the view of cost of operation and of the life of the furnace. To judge which material furnishes the best heat insulator, measurements of the thermal conductivities must be taken at different temperatures.

Investigations made by previous investigators have shown: (1) That the conductivity increases with the firing temperature. For example, silica bricks burnt at 1300° have a conductivity 50 per cent. greater than those burnt at 1050°. (2) That there is an increase in thermal conductivity with temperature for all materials, with perhaps the exception of chromite brick, in which case the conductivity is nearly constant. (3) That the conductivities of

carborundum ($\text{SiC}=87$ per cent., $\text{SiO}_2=12$ per cent.) and graphite ($\text{C}=48$ per cent., $\text{SiO}_2=30$ per cent.) bricks are of the order of four to six times those of fireclay bricks.

The author has investigated the conductivity of materials by heating one surface of a brick of the material in molten metal (tin), the temperature of which was measured by a platinum-platinum iridium couple. The free surface of the tin stood at a level of about 2 mm., above the immersed surface of the brick.

Of the variety of materials tested with this apparatus, those of greatest interest in connection with furnace insulation are: (1) diatomaceous brick; (2) slag wool or silicate of cotton mats, a compressible packing material. The principal constituent of diatomaceous brick is widely distributed, and is known by a variety of names, such as diatomite, kieselguhr, infusorial earth, etc. After calcination, the raw material is a light grey powder composed of about 92 per cent. of SiO_2 , the remainder being oxides of iron, aluminium, calcium, and of the alkali metals. For making up into bricks, the powder is mixed with a little clay to act as binder, then moulded, and fired at a temperature in the neighbourhood of 900° .

Diatomaceous Brick.

Temp. hot face	Temp. cold face.	Mean temp.	Conductivity in C.G.S. unit.
186°	24°	105°	0-000310
261	26	144	0-000318
275	26	150	0-000317
287	25	156	0-000331
453	27	246	0-000360
517	28	272	0-000371
622	32	327	0-000384
893	62	478	0-000447
939	64	502	0-000461

The efficiency of the material as an insulator is largely determined by the air spaces enclosed in the minute cells of the material, so that the conductivity varies with the degree of grinding.

Slag-wool is a fibrous material resembling cotton-wool in appearance. It is manufactured by blowing steam through molten blast-furnace slag. Its chemical composition is $\text{CaO}=36$ per cent., $\text{Al}_2\text{O}_3=23.5$ per cent., $\text{SiO}_2=31$ per cent.

As in the case of the diatomaceous brick, the conductivity increases with temperature. For example, with temperature of hot face 324° and cold face 65° , the conductivity is 0-000191 C.G.S. unit, whilst with the hot face 723° and the cold face 204° the conductivity is 0-000323 C.G.S. unit.

White magnesia is another material of low thermal conductivity (0-00017 C.G.S. unit between 20° and 350°), which is used for steam-pipe covering and similar purposes. It cannot be used at high temperatures without undergoing chemical decomposition and a corresponding increase in conductivity. This, however, does not

limit the use of magnesia to low temperatures, since in the majority of cases there is a considerable gradient through the material, and only a small layer nearest the hot region reaches the decomposition stage.

A. M. J.

49. The Deterioration of Refractory Materials in the Iron and Steel Industries. H. B. CRONSEAW (*Trans. Faraday Soc.*, 1917, 12, 237).—One cause of deterioration of the refractory materials used in the construction of furnaces is to be found in the fluxing influence of basic dust and volatilised compounds derived from various sources, but chiefly from the charges.

Care should be taken to keep the amount of fine dust produced during charging, etc., as low as possible, or suppress it before it can come in contact with the brickwork. (This applies more particularly to regenerators, and an arrangement has been devised for eliminating the dust before it reaches the chequer-work.)

Another way would be so to adjust the composition of the bricks as to be neutral towards the dust.

Fluxing of the furnace material is also brought about by actual contact with the fused charges. To resist these influences, the composition and texture of the furnace must be adjusted accordingly.

In addition to the destructive forces which act chemically, there are others the action of which is mechanical or physical in nature. Such forces, varying from point to point in different furnaces, occasionally become of first importance. Such are abrasion, differential movements, and permeability.

Abrasion is considerably assisted by the formation of friable "scar" and by careless charging. Differential movements, besides leading to general disintegration, tend to open up cracks and joints for the entrance of corrosive slags and vapours. The existence of any degree of permeability assists fluxing. Regulation of temperature is also an important factor controlling the deterioration of a refractory material.

A. M. J.

50. Refractory Materials. SIR ROBERT HADFIELD (*Trans. Faraday Soc.*, 1917, 12, 86).—An address introductory to a discussion on the subject, not capable of abstraction. In addition to valuable notes, the paper contains photomicrographs, several tables of composition of refractories, and a comprehensive bibliography.

W. E. S. T.

51. Suggested Improvements in the Manufacture of Silica Bricks. C. E. NESBITT and M. L. BELL (*British Clay Worker*, 1917, 26, 104).—With the view of studying the effect of fineness of the material used and of pressure during the manufacture of the brick, an experimental series of silica bricks was made with these two factors as the only variables. The ganister was ground dry in three lots to pass a 12-, 8-, and 4-mesh screen respectively. From each of these grades, bricks were made in a

hydraulic press at eight different pressures varying from 187 to 2,500 lb. per square inch. Impact, spalling, and slag penetration tests were carried out on each type of brick, and the results showed that little is gained by increasing the pressure and that both spalling loss and resistance to impact increase with increasing fineness.

The authors recommend the manufacture of power-pressed bricks from ganister ground to pass a 4-mesh screen.

Most defects in firebricks are due, according to the authors, either to bad moulding or to bad firing. For manufacturing practice, the authors suggest the following procedure.

The ganister should be carefully selected and sorted; all rock that is soft or which carries iron, clay, sandstone, or other foreign matter should be rejected. The selected ganister should be ground just to pass a 4-mesh screen, care being taken to avoid an excessive amount of finely-ground material. To insure uniformity, frequent sieve tests of the mud should be made. To secure a sufficient bond, 1.75 to 2 per cent. of lime should be used. In order to avoid irregular shapes and moulding defects, 9 to 11 per cent. of water should be used for hand-made bricks, and the material should be pounded into the mould. The bricks should be thoroughly dried before firing. Great care should be used when heating, especially during the first stage, to prevent fire cracks; this applies also to the cooling.

J. D. C.

VII.—Chemical Analysis.

52. Some Rapid Methods for Glass Analysis. E. C. SULLIVAN and W. C. TAYLOR (*Chem. News*, 1915, 111, 64).—The method first developed was for the analysis of lead glasses which contained varying amounts of silica, lead, soda and potash, and only traces of other substances. For such glasses, the method was to place 1 gram of finely-powdered glass in a platinum crucible of about 40 c.c. capacity, moisten it with water, add 2 grams of oxalic acid crystals and about 20 c.c. of 48 per cent. hydrofluoric acid, and then evaporate to dryness on a radiator (see below) the temperature of which is just high enough to expel the excess of oxalic acid. When the acid has been expelled and the crucible cooled, the evaporation is repeated twice with oxalic acid and water. About 5 grams of oxalic acid are used in all, and a blank experiment for alkalis is carried out on this quantity of acid. When all the acid has been expelled after the third evaporation, the remaining oxalates are taken up with water, the solution allowed to cool, and filtered. The residue, which, in the case of these glasses, consists of PbC_2O_4 only, with a trace of CaC_2O_4 , may be titrated directly with potassium permanganate or dissolved in dilute nitric acid and estimated as sulphate.

The filtrate from the PbC_2O_4 is evaporated to dryness in a platinum dish and the residue heated over a free flame until the oxalates are decomposed. Then the carbonates are dissolved with water and hydrochloric acid and evaporated to dryness to remove the small amount of silica which is usually present. The filtrate from the silica is oxidised by heating with bromine water, and ammonia is added in order to precipitate iron, aluminium, and manganese. The precipitate is filtered off and the filtrate divided into two equal parts. To one portion microcosmic salt solution and ammonia are added to precipitate magnesium. From the weight of precipitate the amount of magnesium chloride originally present is calculated. The second portion is evaporated to dryness in a platinum dish, ignited gently to drive off the ammonium salts, and the weight of alkaline chlorides remaining are determined after subtracting the weight of the magnesium chloride present and the oxalic acid blank. The potash is determined in the usual way.

The authors found the above method satisfactory for simple lead glasses. Checks were made by analysing some of the glasses by the above method and also by the usual methods. The results are given in the paper. It is suggested that the method may be capable of further application, and the results of attempts to do so are mentioned and discussed.

To apply this method to other types of glasses, the procedure following the three evaporations must be varied. The oxalates which the authors have worked with group themselves as follows:—

	<i>Insoluble.</i>	
Lead	Cadmium ¹	Magnesium ²
Calcium	Copper ²	Nickel ²
Zinc	Cobalt ²	Barium ²
	<i>Soluble.</i>	
Aluminium	Potassium	Manganese ³
Chromium	Arsenic	Iron ⁴
Sodium	Antimony ⁵	

¹ Here the method is almost quantitative, but when zinc is present traces occur with soluble oxalates.

² The oxalates of these metals are mostly insoluble but must be looked for in soluble oxalates.

³ If more than 2 per cent. of manganese is present some will be found with the insoluble oxalates.

⁴ With zinc glasses a trace of iron is often found with the insoluble zinc oxalate.

⁵ Normally soluble but has been found with insoluble oxalates when these have been heated too strongly.

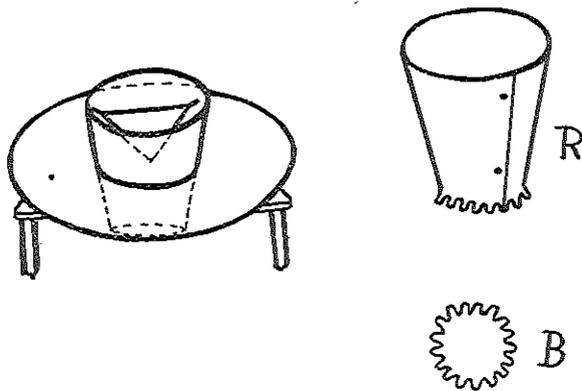
After the separation of the soluble and insoluble oxalates, the procedure depends upon the elements present. The method is satisfactory for simple lime glasses, but the presence of more than 3 per cent. alumina causes difficulty, owing to its interfering with the expulsion of fluorine by oxalic acid. Boric oxide tends to alleviate this trouble, but unless great care is taken with the heating during the evaporation inaccurate results are obtained with

glasses high in alumina, and for this reason the method has no advantage over the usual procedure for such glasses. The method is convenient for the rapid determination of arsenic and antimony.

For the determination of boric oxide, the authors employed Wherry's method. The usual difficulty with this method, namely, the retention of boric oxide by the precipitate from calcium carbonate, was overcome by using suction when washing the precipitate. It was found, however, that calcium carbonate did not completely remove zinc or lead, and therefore when either was present in a glass, the boric oxide result was too high. The following modified method was found to overcome this trouble and to give correct results.

0.5 Gram of glass is fused with 3 grams of Na_2CO_3 , the fusion being continued for one or two minutes after the mass is liquid. The melt is dissolved in 20 to 30 c.c. of hot water, and any insoluble residue filtered off and washed. The filtrate and washings are transferred to a 250 c.c. round-bottomed flask, about 7 c.c. concentrated HCl added, the liquid heated nearly to boiling, and pure dry calcium carbonate in moderate excess added. The liquid is boiled vigorously under a reflux condenser for about ten minutes, filtered, with the aid of suction, through a small Büchner funnel, and the precipitate washed several times with hot water, keeping the total volume of liquid below 100 c.c. The filtrate is returned to the flask, a little calcium carbonate added, and again heated to boiling, and then connected to a filter pump through a splash trap and suction continued until the boiling has nearly ceased. It is then cooled to the ordinary temperature, filtered if the precipitate has a red colour and the boric acid titrated with $N/10$ - NaOH solution until a permanent pink colour was obtained in the presence of excess of mannitol.

[NOTE.—The radiator used by the authors was made up from a description by W. F. Hillebrand in Bulletin No. 422, U.S. Geol.



Survey, p. 31. *R* is of sheet iron, aluminium, or nickel, 6 to 7 cm. high, 8 cm. wide at top, and 5 cm. at bottom. The base *B* may

be of iron, nickel, or platinum, but not of aluminium, which will not withstand the temperature of the direct flame. *B* is attached to *R* by turning the cogs of *B* up and over those of *R*. A platinum triangle should be inserted about 4 cm. from the base. An aluminium ring with an opening slightly larger than the underlying crucible should be placed over the radiator to hasten evaporation.]

J. D. C.

53. The Determination of Iron in Glass Sand. JOHN F. FERGUSON (*J. Ind. Eng. Chem.*, 1917, 9, 941).—The usual method* of determining the iron content has been to digest the sand with hydrofluoric and sulphuric acids repeatedly until all the silica disappears and no gritty particles remain. The hydrofluoric acid is then driven off, and the heating continued until copious fumes of sulphur trioxide are evolved, after which the vessel is allowed to cool, the contents taken up with water and filtered, and the iron determined in the filtrate. This method of attack assumes that the sand is completely decomposed with hydrofluoric acid. Theoretically its validity is doubtful, since a glass sand often contains such minerals as magnetite, ilmenite, tourmaline, staurolite, etc., minerals which do not break up readily under this treatment, and in practice the writer has found that in so-called good sands—sands in which the iron is practically all present in the heavy minerals—the greater part of the iron was lost under such treatment.

The writer recommends the following method of procedure:—

Weigh out 5 grams of the sand in a large platinum crucible, moisten with 5 c.c. 1:1-sulphuric acid, and then add 40 c.c. hydrofluoric acid. Evaporate until white fumes of sulphur trioxide begin to be given off; cool, and if upon examination silica can be seen, add more hydrofluoric acid and repeat the operation. Two such evaporations should suffice, but a third may be necessary. Cool the crucible, dilute the contents, and filter. The black residue will consist principally of carbonaceous matter derived from the hydrofluoric acid, and this black matter will prevent the analyst from ascertaining the completeness of the decomposition. The filter containing this residue, without washing, is dried and ignited in a platinum crucible. The funnel is carefully rinsed with distilled water, and the rinsings allowed to run into the filtrate. After ignition, the residue is fused with a little iron-free potassium bisulphate, and the fused mass dissolved in dilute sulphuric acid. If no residue remains, the decomposition is complete, and the two solutions may be combined and the iron then determined in the resulting solution. If dark particles still remain, and this will be the case if staurolite is present, they are filtered off, ignited, and fused with iron-free sodium carbonate in a platinum crucible. Upon treatment with dilute sulphuric acid, no black particles should be seen, and after filtering to remove any insoluble sulphates, the free filtrates may be combined and the iron determined in the resulting solution. The author prefers to reduce the iron with

* The fusion method is usually adopted in this country.—ED.

stannous chloride and then to titrate with potassium bichromate, determining the end-point electrometrically, and for this reason he dissolves the fused mass in 1:1-hydrochloric acid instead of in sulphuric acid. Other well-known methods, however, would probably give equally good results.

In making such analyses, the purity of the platinum and the reagents becomes a question of prime importance; hence no iron-bearing platinum may be used, and careful blank determinations will eliminate errors due to the latter.

C. M. M.

54. Determination of Boric Acid in Special Glasses.

P. NICOLARDOT and J. BOUDET (*Bull. Soc. chim.*, 1917, 21, 97).—The authors found the following procedure to give satisfactory results.

One gram of finely powdered glass is gently fused with 5 grams of mixed alkali carbonates. When cold the melt is digested with hot water, 5 grams of ammonium chloride are added, and the liquid is boiled for five minutes. The silica is next precipitated by passing in a current of carbon dioxide for ten minutes, the liquid boiled to drive off ammonia and allowed to stand until the precipitate has settled, and then filtered. The precipitate contains the silica and certain bases (for example, those of zinc, magnesium, calcium, and aluminium), the boric acid remaining in solution. The precipitate is washed with dilute ammonium chloride solution. To the filtrate and washings 5 grams of pure sodium hydroxide are added, and the liquid is heated to decompose ammonium salts and evaporated to a volume of 100 c.c. The liquid is transferred to a 500 c.c. flask, neutralised with hydrochloric acid (using methyl-orange as indicator), and boiled for fifteen minutes beneath a reflux condenser to expel carbon dioxide. When cool, one drop of methyl-orange solution is added and *N*/10-sodium hydroxide solution (free from carbon dioxide) run in until the indicator turns yellow. Ten c.c. of glycerine or 0.8 gram of mannitol freshly dissolved in boiling water are then added, and the titration is completed, using phenolphthalein as indicator.

The presence of magnesia or alumina does not interfere with the determination of boric acid by this method, or by the method of distillation as methyl borate.

J. D. C.

55. The Separation of Aluminium from Iron by means of Ether.

SAMUEL PALKIN (*J. Ind. Eng. Chem.*, 1917, 9, 951).—The method proposed in this paper depends on the insolubility in organic solvents of hydrated aluminium chloride as contrasted with that of iron. The medium is entirely an organic solvent, except for traces of moisture introduced by the solvents.

The chlorides of iron and aluminium (not more than 0.5 gram total) are evaporated to dryness on a steam-bath in a 150 c.c. Erlenmeyer flask, the residue being stirred occasionally with a glass rod, which is allowed to remain in the flask. The residue is then further dried in an oven at about 120° for half an hour,

stirring it from time to time. When dry, the residue is moistened with 0.5 c.c. to 1 c.c. of absolute alcoholic HCl solution, prepared by saturating absolute alcohol with HCl gas, the gas being conveniently generated by the action of concentrated H_2SO_4 on anhydrous calcium chloride. The mixture is warmed on a steam-bath and stirred to convert any oxides to chlorides, then 3 to 4 c.c. of absolute alcohol are added, and the flask is heated on the steam-bath until all salts have gone into solution. When $AlCl_3$ is present to the extent of nearly 0.5 gram and very little iron, it is sometimes very difficult to get all salts into solution. With small amounts of iron present, however, the last traces of $AlCl_3$ need not pass into solution.

When this has been accomplished, the flask is allowed to remain on the steam-bath until the salts begin to crystallise out and the resulting residue is quite viscous, but not solid. About 0.5 c.c. of alcoholic HCl solution is now added, the flask again warmed, and the residue stirred, so that the mass is uniformly impregnated with the HCl. The flask is then removed and 30 c.c. of ether (sp. gr. 0.713 to 0.716 at 25°) are added gradually with stirring. The hydrated aluminium chloride should come down as a uniform, granular, white precipitate, leaving the supernatant liquid clear. Forty c.c. of absolute ether are then added with stirring, and the flask allowed to stand. When the precipitate has settled, the solution is filtered through a Gooch crucible into a 250 to 300 c.c. Erlenmeyer flask. The crucible is fitted preferably with a small circular filter paper instead of asbestos. The flask should be washed with wash-ether (100 parts of absolute ether and 2 parts of alcoholic HCl) during filtration to prevent any ferric chloride drying on the white precipitate or on the crucible. The usual precautions of washing the flask, crucible, and funnel are taken to complete transfer of iron. It is not necessary, however, to transfer all the aluminium chloride precipitate to the Gooch crucible. The aluminium precipitate is transferred with the paper from the crucible into a 250 c.c. beaker, and then washed with water to remove adhering particles. The original flask is also washed into the beaker. The liquid is diluted to approximately 100 c.c., 5 grams of ammonium nitrate are dissolved in it and made just alkaline with ammonia (using methyl-red as indicator, preferably), boiled, and filtered, and the precipitate is washed in the usual way. The precipitate is ignited in a covered crucible and weighed as Al_2O_3 . The ether solution of iron is distilled or evaporated to remove the ether. The residue is transferred with a little water and HCl to a weighed platinum dish, using as little water as possible, and evaporated to dryness on the steam-bath, moistened with 1 c.c. of concentrated H_2SO_4 , warmed on the steam-bath gently to expel most of the HCl, and then slowly over a flame until all the ferric chloride is converted to sulphate and no further fuming of H_2SO_4 takes place. The dish is then heated over a free flame and finally over a blast to convert the sulphate into ferric oxide.

C. M. M.

56. A Rapid Method for the Determination of Lime as Calcium Sulphate. L. G. WILLIS and W. H. MACINTYRE (*J. Ind. Eng. Chem.*, 1917, 9, 1114).—The determination of lime by weighing as sulphate possesses distinct advantages, and its accuracy is vouched for by several tests. The use of a factor and the constancy of the sulphate commend the method to analysts. The technique of the method is as follows.

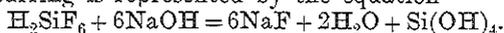
The lime is carefully precipitated as oxalate, dissolved, and reprecipitated (if the magnesium content is appreciable), and the precipitate ignited until the filter is completely incinerated. For each approximate 0.2 gram of CaCO_3 enough of a finely ground and dried mixture consisting of equal parts of ammonium sulphate and ammonium chloride is added to ensure an excess of approximately 0.3 gram of sulphate, and the precipitate and fusion mixture are thoroughly incorporated by means of a glass rod. The volatilisation of the excess of salts may be efficiently carried out by inserting the crucible in a circular opening cut in a piece of asbestos board and directing a nearly horizontal flame from a small Bunsen burner across the surface of the crucible in such a manner as to have the side of the crucible nearest the flame intensely heated. The conducted heat will effect volatilisation without causing spattering. After volatilisation is complete, the crucible is cooled and the precipitate weighed as calcium sulphate.

Should duplicates fail to agree within a few tenths of a milligram, the analyst may verify the results by moistening the ignited CaSO_4 with a few drops of 1:10 sulphuric acid, evaporating excess of water, and again igniting.

It was also found that a mixture of ammonium chloride and ammonium sulphate affords a most satisfactory conversion mixture which gives very accurate results. Care must be taken with the ignition, as at a bright red heat fusion with loss of SO_3 ensues, but no loss in weight occurs at a dull red heat. C. M. M.

57. A Modified Method for the Determination of Fluorine, with Special Application to the Analysis of Phosphates. CARY R. WAGNER and WILLIAM H. ROSS (*J. Ind. Eng. Chem.*, 1917, 9, 1116).—The authors have devised a modified method applicable to substances containing only a small percentage of fluorine. Results accurate to within 0.0005 gram of fluorine may be expected, and, if organic matter is carefully excluded, even greater accuracy may be secured. The lowest limit to which the method is applicable may be taken as 0.01 per cent.

A suitable apparatus for this method is described by the authors. The fluoride compound is heated with silica and 98.5 per cent. sulphuric acid in the presence of a dehydrating agent, namely, anhydrous copper sulphate. The silicon tetrafluoride is driven through the apparatus by a flow of carbon dioxide, and collected in an absorption tube containing water. It is then titrated with *N*/10-sodium hydroxide, using phenolphthalein as indicator. The reaction occurring is represented by the equation



In the presence of phosphoric acid, the solution must first be prepared by making it neutral to phenolphthalein with sodium hydroxide and then drying.

If desired, the results obtained by the above method may be checked by means of a gravimetric method, in which the fluoride is precipitated by means of lead chloride and weighed as $PbFCl$.

C. M. M.

58. The Titration of Magnesium. F. W. BRUCKMILLER (*Chem. News*, 1917, 115, 301).—Two methods are described by the author. In the first, the magnesium is precipitated with microcosmic salt, the precipitate dissolved in a known volume of standard acid, and the excess of acid titrated with standard alkali. To obtain a correct result, the precipitation must be carried out in a solution fairly free from ammonium salts, and the precipitate must consist wholly of $MgNH_4PO_4$. The procedure recommended is as follows:—The solution containing magnesium is evaporated to dryness, and the ammonium salts are removed by heating. The residue is taken up in a small volume of water, acidified with hydrochloric acid, and, after filtering, if necessary, made slightly ammoniacal. Microcosmic salt solution is added to the cold solution with stirring, and after the precipitate has formed, a volume of strong ammonia equal to one-third of the total volume added, and the solution allowed to stand for eighteen hours. The precipitate is then filtered on a good quality filter paper with the aid of suction, and washed with 25 c.c. of alcohol. The precipitate is washed with hot water from the filter into the beaker in which the precipitation took place. A known excess of $0.10N HCl$ is added, and the excess titrated back with $0.10N NaOH$, using methyl-orange as indicator. The standard acid reacts with the $PO_4^{'''}$ ion in the precipitate, giving H_2PO_4' , which is neutral to methyl-orange. Therefore 1 c.c. of $0.10N HCl$ is equivalent to 1.2 mg. of magnesium or 2 mg. of magnesium oxide.

The second method consists in precipitating the magnesium as arsenate, the arsenate being estimated by titrating the iodine which it liberates when potassium iodide is added to the acidified solution.

J. D. C.

59. The Dehydration and Recovery of Silica in Analysis. F. A. GOOCH, F. C. RECHERT, and S. B. KUZIRIAN (*Chem. News*, 1914, 110, 202).—As a result of a large number of experiments, the authors draw the conclusion that the slight variations in weight obtained when silica precipitates, which have been ignited with the Bunsen burner, are submitted to the temperature of the blast-lamp, are due to the presence of sodium chloride, which by strong ignition is either transformed into sodium silicate or is partially volatilised, and not to the obstinate retention of moisture.

After fusion with sodium carbonate, silica cannot be completely recovered by one evaporation. The authors believe that the insolubility of the silica and the purity of the washed precipitate are

increased by complete desiccation, and they recommend dehydration at 110° after both evaporations. In their experiments, the average result for the second silica precipitate was 5.1 mg. J. D. C.

60. Stellite as a Substitute for Platinum. ELWOOD HAYNES (*J. Ind. Eng. Chem.*, 1917, 9, 974).—Owing to the great scarcity of platinum, and its consequent high price, platinum substitutes have been eagerly sought, although probably no single metal or combination of metals will fully take its place.

The stellite alloys are not fixed or definite in their composition, and may be divided broadly into two classes: (1) those malleable at a red heat, and (2) those which can be worked into the desired form only by casting.

The malleable alloys are composed almost entirely of cobalt and chromium only, though the proportion of the constituents may vary from 10 to 50 per cent. of chromium, with a corresponding variation in the cobalt content. These alloys are all hard, and may be scratched by the file, but none of them is practically workable by this means. They resist nitric acid almost perfectly, even when boiling, particularly if the chromium content is more than 15 per cent. They may be forged only with difficulty, at temperatures ranging from 750° to 1200°. They are all slowly attacked by hydrochloric, sulphuric, and hydrofluoric acids, but are nearly immune to all chemical combinations, as well as to the fruit acids. They prove suitable for evaporating many chemical salts to dryness, and particularly for boiling the caustic alkalies. Substances may be evaporated to complete dryness in these vessels without any danger whatever of breaking, since the tensile strength of the alloy exceeds 100,000 lb. to the square inch. They can be subjected to temperatures up to 1200° and still retain a considerable amount of strength. In fact, the stellite alloys possess the highest "red hardness" of any of the alloys yet discovered. C. M. M.

VIII. General.

61. Discussion on the Softening of Water. (*J. Soc. Chem. Ind.*, 1917, 36, 910).—The paper deals with the various problems which arise in connection with water-softening plants and the distribution of softened water from them.

Proper chemical control of water-softening plants is most necessary, otherwise the water may be inefficiently softened or a large excess of chemicals may be present in the resulting water. The applicability of any automatic appliance for the addition of the chemicals required is difficult, since the water is often liable to

serious fluctuations in composition, whilst such difficulties as the clogging of measuring buckets, irregularities in the content of suspensions, and alteration in the diameter of the measuring aperture have to be faced. A softening medium containing milk of lime requires constant agitation to avoid uneven solution; also water softened by such a medium requires to be in a settling tank for some time and then filtered to remove precipitated matter. A wood-wool filter in the upper part of the settling tank proves an efficient filter, but needs frequent flushing and removal for cleaning.

The permutite process appears to be the ideal one for softening crude water; at the present time, permutite plants are installed to remove the remaining hardness after a lime and soda treatment.

Water passing through permutite should be practically iron-free, but the preliminary lime and soda treatment does not always secure this. It has been suggested that the iron in waters should be passed through a manganese-permutite, which always oxidises any ferrous salt and completely removes the per-salt so formed.

Permutite with water containing much carbonate of lime produces an alkaline effluent which is disastrous for some purposes (tanning and some branches of dyeing). A highly-softened water appears to initiate or aggravate corrosion of service pipes and boilers and also increases the tendency to "priming" in the boiler of a water heavily laden with sodium salts. The difficulty with the pipes renders it debatable as to whether in a large establishment central softening followed by distribution through pipes is better or worse than the use of separate plants for particular installations. For boilers, the best method appears to be to soften the water to five or six degrees of hardness, and then to use an organic boiler compound (tannin refuse, potatoes, or substance of a colloidal character) in the boiler.

Methyl-red may be used as an indicator for the determination of the hardness of water (*J. Soc. Chem. Ind.*, 1915, **34**, 1028, and 1916, **35**, 445; also *Collegium*, 1915, p. 237, London ed.).

A. M. J.

Reviews.

Glass and Glass Manufacture. By P. MARSON (*Published by Sir Isaac Pitman and Sons, Ltd.*, 1918. 2s. net).—This little volume is one of the "Common Commodities and Industries" series published by Messrs. Pitman. It is written by a practical man and has both the defects and the advantages of such authorship. The author does not attempt to give the scientific explanations underlying the processes of glass manufacture, and the early sections of the book contain a number of loose expressions which should be eliminated if the preciseness which is desirable in a well-founded industry is to be encouraged. Thus, p. 10, "tin oxide and antimony oxide are used as opacifiers. . . . Used in small quantities they have a favourable influence in the development of ruby-coloured glasses"; but no mention is made of the fact that the oxide which produces opalescence is not the same as that used in ruby glasses. Again, manganese, manganese dioxide, and manganese oxide are frequently used indiscriminately for the same substance. On p. 26 occurs the statement, "silicate of soda and barytes." The table of formulæ and molecular weights on p. 14 seems quite irrelevant to the text, and in any case it may be remarked that NiO_2 does not exist, and the nickel oxide used as a decoloriser is either NiO or the sesquioxide, Ni_2O_3 . There is also a slip in the formula for sodium fluoride, which is given as " NaF_2 ." The statement, p. 19, that glasses high in lead are readily attacked by the acid vapours met with in the atmosphere, is scarcely correct.

In the practical sections of the book, the author is thoroughly at home, and the descriptions of operations are both good and clear. Tank furnaces are dismissed in two pages, whilst the only machine for bottle-making described is the Schiller (termed "Harlington"). But in the compass of some 120 pages the author gives an account of the industry from which there are few manufacturers who will not derive useful information. The clearness of the illustrations is to be commended.

For a second edition, better proof reading is desirable. Misspellings are numerous, such as "Strassfurt" for "Stassfurt," "Calliches" for "Caliche," "oxidisation," etc., whilst the appendix containing books of reference is badly marred by mistakes, including "Spreechall" for "Sprechsaal." These defects detract from what is, on the whole, a useful little book. W. E. S. T.

Refractory Materials, their Manufacture and Uses. By A. B. SEARLE. *Published by Messrs. C. Griffin and Co., Ltd.* 15s. net.—The refractories industry is one which, like the glass industry, had to wait until the war before its importance to the country could be really appreciated. In view of the interest now aroused in the subject, the publication of the present volume by one who has made a long and close study of the subject is indeed welcome.

The book contains eighteen chapters devoted to the raw materials; the manufacture of firebricks from clay; silica firebricks; basic bricks; bauxite and other highly aluminous bricks; carbon bricks; bricks made of chromite or iron ore; carbide and carboxide bricks; refractory blocks, slabs, and hollow ware; saggers; muffles; crucibles and scorifiers; glass pots; retorts; fused silica ware; refractory porcelain; refractory mortars and cements; the selection and application of refractory materials. Whilst there are one or two slips, almost inevitable in a book containing such a mass of detail, the work is well done.

The acquaintance of glass manufacturers with suitable refractory materials has not hitherto been very wide. A careful study of this volume will be found most suggestive and stimulating.

W. E. S. T.

I.—Glass-making Materials.

62. Recovery of Potash from Greensand. H. W. CHARLTO (*J. Ind. Eng. Chem.*, 1918, 10, 6).—The advantage of obtaining potash from this source is that the residue can be profitably employed as a building material which has an unlimited market, as well as being a superior product capable of being manufactured at a remarkably reasonable price.

The method consists in digesting under pressure finely ground *glauconite*, commonly called greensand, with lime and water, thereby obtaining caustic potash of great purity and at the same time converting the residue into a material of value.

The reaction is carried out in large digesters or autoclaves, heated by introducing into the charge high-pressure steam in sufficient quantity to maintain the desired pressure of about 225 lb. for a period of from two to four hours, after which the contents are filtered to separate the dissolved caustic potash from the insoluble residue. On filtering, the potash appears in the filtrate as potassium hydrate associated with so few impurities that on concentration it may be sold as a high-grade product without further treatment.

The employment of greensand rather than felspar has one or two decided advantages. In the first place, greensand is almost soda-free, so that the difficult and expensive separation of the alkalis is avoided. Also the small amount of alumina shown to be present in greensand by analysis must be present in some combination which is unaffected by the above process. This is extremely fortunate.

Greensand contains usually from 6 to 7 per cent. of K_2O , and it may be almost completely recovered, but it is found that 70 to 80 per cent. of the total potash is a satisfactory yield after considering such factors as dilution, time of digestion, etc. This means the production of about 100 lb. of K_2O , and binder material for from twenty to thirty thousand bricks from each ton of greensand.

C. M. M.

63. Effect of Coal Ash on the Liberation and Nature of Cement Mill Potash. N. S. POTTER, jr., and R. D. CHEESMAN (*J. Ind. Eng. Chem.*, 1918, 10, 109).—The potash collected from the kiln stack gases where coal is used for burning appears in practically two forms, water-soluble potash and the insoluble or slowly soluble potash. The insoluble potash has been attributed to two causes: the potash in the unburned or partly calcined raw material carried over mechanically in the gases, and a recombination of the volatilised potash with the finely divided ash particles of the coal.

Analyses of the ash from coal burned in the kiln bring out the fact that the potash content of the ash is considerable and to such an extent that it must be taken seriously into consideration, there

being an average of 5 per cent. Owing to the very finely divided state of the ash particles and the velocity of the gases in the kiln, only a very small percentage of the ash is deposited there, nearly all passing out with the gases. It is observed also that the percentage deposited in the kiln is undoubtedly higher in mills using the wet processes, where the ash particles have a tendency to cling to the wet slurry.

As the velocity of the kiln gases is quite high, the ash particles will be exposed to the intense heat of the firing zone of the kiln for only a fraction of a minute. Further, the combustion being exothermic precludes the possibility of a very high temperature being attained by the ash particles. Such being the case, there should be practically no volatilisation of the potash in the ashes from the coal in the kilns.

Again, taking into consideration the potash content of the ash and of the raw mix carried over mechanically, the authors conclude that there is apparently no "recombination" of the volatilised potash with the siliceous ash particles.

C. M. M.

64. The Direct Heat Treatment of Cement Mill Dust to increase its Water-soluble Potash Content. ALBERT R. MERZ (*J. Ind. Eng. Chem.*, 1918, 10, 186).—Since commercial grades of any insoluble potash silicate in quantity contain comparatively small percentages of potash, no process for recovering the latter from such material can offer much promise of profitable application unless in addition there is also produced some other product of value. Three factors determine the profitable recovery of potash and must be considered in any attempt advantageously to obtain it as a by-product in the cement industry, namely, liberation of the potash, recombination, and collection. The work presented here, however, deals only with a method for making the "recombined" potash of cement dust soluble in water. The term "water-soluble potash" as used above refers to that potash which is obtained in solution when 10 grams of the sample are boiled with 300 c.c. of water for thirty minutes and the volume is subsequently increased to 500 c.c.

Potassium compounds occurring in cement dust may be divided into three groups:—(1) those, which are readily water-soluble, (2) those which are slowly soluble, and (3) those which are insoluble. The insoluble potash represents the combinations occurring in the original silicates of the raw mix carried over mechanically in the dust before being subjected to a temperature sufficiently high to bring about decomposition. The form of combination which is slowly soluble in water has been attributed to the recombination of the volatilised potash with the finely divided incandescent particles of siliceous coal ash carried over in the dust, and it is claimed to be proportional to the amount of coal ash present in the gases from the kiln. Hence dusts from cement mills using coal as fuel have considerable proportions of their potash content in a form not readily water-soluble.

The author found that by simple ignition of the dust the water-soluble potash of one sample of dust was increased from 60 per cent. to 91 per cent. of the total potash content. In all cases he found that the ignition of dusts from cement mills in an oxidising atmosphere at temperatures of 600—1100° converts the "recombined" potash into a readily water-soluble form. Further, the time of ignition apparently has little effect on the water-soluble content of the resultant product.

C. M. M.

65. The Extraction of Potash and other Constituents from Sea-water Bittern. JOEL H. HILDEBRAND (*J. Ind. Eng. Chem.*, 1918, 10, 96).—It is estimated that the amount of potash that could be extracted from the bitterns of the salt works on San Francisco Bay alone would add about 10 per cent. to the United States present annual production, an amount which at this time of acute shortage of potassium salts is of considerable importance.

A general outline of the classic work of van't Hoff and his co-workers on the solubility relationships of the various salts obtainable from sea-water is given by the author, and upon its basis he formulates methods for the recovery of the constituents of bittern. Numerous tables and diagrams are given showing composition, temperature of separation, and the phases present for various types of crystallisation.

C. M. M.

66. Recovery of Potash from Blast Furnace Dust. R. A. BERRY and D. N. McARTHUR (*J. Soc. Chem. Ind.*, 1918, 37, 111).—The authors deal with this problem as it affects Scotland, where the potash content of the iron ore used is probably lower than in England, and where coal instead of coke is normally used, in which case much tarry matter is produced.

As the amount of dust produced in the Scottish practice is relatively very small, the spent liquor, which according to Wysor is the main avenue of loss, seems more deserving of attention. The heavy, tarry matter was precipitated with all the dust, and thus a partial cleansing of the gas was effected. The pitch was then burnt. The potash content of the ash was high, the average being 33.5 per cent., but the yield of ash was disappointing. The potassium salts, present mainly as sulphate and chloride, and in one or two cases as carbonate, could be extracted with water, or the ash, without further treatment, might be used as a manure.

In the samples of flue dust analysed the potash content was low, namely, 3.13 per cent. In stone dusts the yields were negligible. The ash from tube cleanings contained only a very small percentage of water-soluble potash, but the value of these dusts is high in comparison with the others on account of the great quantities of cleanings annually produced.

In any scheme of development, after war conditions have passed away, it must always be borne in mind that if the Alsatian deposits come into the occupation of their rightful owners, there will be an

almost unlimited supply of potash, irrespective of the deposits in Germany.
C. M. M.

67. Recovery of Potash from Wool-scouring Waste.

ROBERT SPURR WESTON (*J. Soc. Chem. Ind.*, 1918, 37, 177).—At one time the only practical method of treating wool-scouring waste was to precipitate the solids with sulphuric acid or acid sodium sulphate. The precipitated sludge was then dried on sand beds and the grease recovered from it by pressing in steam-jacketed hydraulic presses. The potash in the supernatant liquid is in the form of sulphate, but the liquor contains much other mineral matter and free acid, and no method has yet been devised to recover the potash economically.

Since the war this "cracking" process has been modified, and among the many methods considered, three main types have been described, in all of which cases the potash is recovered by washing out. In the author's opinion it is the introduction of the centrifugal machine which makes the recovery of potash possible. Former attempts to recover potash from wool-scouring waste failed because of the formation of an impure, vitreous potassium silicate during calcination.

The process which is usually recommended is to evaporate in a triple-effect of proper design, degrease the concentrated liquid with an immiscible solvent, distil off the latter from both aqueous and solvent layers, and then coke the aqueous concentrate in an open pan heated by fuel oil. The incinerated mass is a porous, grey, non-hygroscopic solid, which may be ground and lixiviated for the production of a nearly colourless solution of potassium and sodium carbonates, which is nearly free from silica and from which some 20 per cent. of the potassium salt may be recovered by fractional crystallisation.
C. M. M.

68. The Use of Zinc Sulphide in White and Luminous Enamels.

J. SCHAEFER (*Ker. Rundschau*, 1917, 25, 75).—The author discusses the use of sulphide of zinc as an opacifying agent in place of oxides of tin and zirconium. The experiments, which were conducted in connection with enamels for sheet iron, show that, in a suitable enamel, zinc sulphide is an excellent opacifying agent when not used in conjunction with other metallic oxides which tend to decompose it. The opacity is due to zinc sulphide as such, and not to zinc oxide produced by oxidation. Further, it is equal to that obtained by tin oxide, although the zinc sulphide enamels have not the whiteness and brilliancy of tin enamels.

Zinc sulphide as an opacifying agent cannot be used in coloured enamels, or those containing oxides of lead, arsenic, antimony, or manganese.

Luminous zinc sulphide may be incorporated into an enamel without losing its luminosity, and the luminous enamels so formed retain their power for years with only very slight loss of luminosity.

J. H. D.

II.—Glass: Manufacture and Properties.

69. Selenium as Decolorising Agent. W. FROMMEL (*Ker. Rundschau*, 1917, 25, 95).—Selenium may be used as a decoloriser in any one of three forms, namely, black selenium, red selenium, or sodium selenite. The author discusses the properties of these materials, and points out that black and red selenium are allotropic forms of the element, and not, as frequently supposed, specially prepared mixtures containing other decolorisers. The red form changes into the black one at 97°. Selenium melts at 217° and vaporises at 700°. Sodium selenite is a white, hygroscopic powder containing 45·7 per cent. of selenium.

The author claims that glasses decolorised by selenium are more brilliant than similar glasses in which manganese or nickel oxides have been used as decoloriser. The decolorising action of selenium is due to the presence of the element in the form of extremely minute particles throughout the glass. These particles tend to give a red colour to the glass, and this neutralises the faint green coloration caused by the presence of iron as impurity in the raw materials used.

Since selenium is oxidised readily, it can only be used with advantage under slightly reducing conditions, or at least in the absence of oxidising agents. The use of white arsenic is recommended as the most suitable reducing agent, and the batch should not contain nitre or similar oxidising agents.

It will be understood, therefore, that selenium is not a suitable decoloriser for lead glasses.

When added in the form of sodium selenite, this salt is decomposed by the sand with liberation of selenium dioxide, which is then reduced to selenium, either by arsenic in the batch or by the furnace gases. The quantity to be used varies with the amount of iron in the raw materials, but according to experiments the colouring effect of 1 kilogram of iron oxide can be neutralised by 0·208 gram of selenium. For ordinary glass of good quality, 0·1 gram of selenium or 0·2 gram of sodium selenite may be used to decolorise 250 kilograms of glass, but even when used in considerable excess no observable overcolouring is noticed.

As the quantities used are so small, the selenium should be mixed with a portion of some of the other batch materials, for example, limespar or soda, before being added to the full batch. If sodium selenite is used, it may be dissolved in water and added to the sand, or simply ground up with some of the dry sand. The portion of batch containing the decoloriser should be added to the pot at the second filling on.

Opinions vary as to the advisability of "bubbling" a pot containing selenium, but in general it may safely be done and will remove any overcolouring.

Glasses decolorised by selenium may usually be detected by their

brilliance and by the reddish tinge they assume on prolonged heating.

Some hints are given for detecting the selenium in glass by qualitative analysis (the quantitative estimation is not of much value, since some of the selenium added escapes during the melting) and also for testing the purity of commercial samples.

Glasses decolorised by selenium have the disadvantage that they assume a brownish tinge on prolonged exposure to bright sunlight.

J. H. D.

70. Small Continuous Tank Furnaces for Glass Melting.

H. SCHALL (*Ker. Rundschau*, 1917, 25, 47).—The author points out the difficulty met with in using a tank furnace of the usual construction when a comparatively small output of glass is required. If the tank is very small, either the fine glass will be too hot to be worked properly or, if the temperature is sufficiently reduced to counteract this, the glass may not be properly melted and plain. In such cases it is usual to resort to a "day" tank with alternate melting and working periods. Such intermittent tanks consume considerably more fuel than a continuous tank. The tank described in the article is quite small, and fireclay tubes which dip deeply below the surface of the metal in the tank are built into the walls and serve as working holes. The batch is filled into the tank outside these tubes, melts in the ordinary way, and sinks to the bottom of the tank, rising up the fireclay tubes as their contents are withdrawn by the workmen. In this way, melting and working out can be carried on simultaneously in a small tank, and the workmen are not exposed to the heat of the furnace to such an extent as when the ordinary open working holes are used. Such tanks must be deeper than the ordinary open tank. With a glass surface 6 metres \times 3 metres, 7 tons of glass can be melted within twenty-four hours, with a fuel consumption of 5 tons of coal.

J. H. D.

71. The Effect of Fluorspar in Glass (*Ker. Rundschau*, 1917, 25, 63).—A discussion on the subject, from which the following conclusions emerge. The addition of fluorspar to a glass batch reduces the melting point of the latter, since the fluorine in the fluorspar unites with some of the silicon in the sand and escapes as gaseous silicon fluoride, whilst the calcium remains as calcium silicate in the glass. The net result of using fluorspar in a batch, therefore, is to reduce the silica and increase the lime content of the glass, making the latter more readily fusible, but of inferior quality and less resistant. The formation and escape of the silicon fluoride take place at high temperatures and assist in fining the glass. Fluorspar has a corrosive action on the pots, and should never be used in greater proportion than 10 parts to 100 parts of sand.

When used in small quantities, practically the whole of the fluoride is decomposed, but in special circumstances the decomposi-

tion of the fluorspar is incomplete, and fluorine compounds remain in the glass, giving special properties to it; for example, a very low refractive index. It is therefore useful for some kinds of optical glass.

The silicon fluoride may have an action on the furnace flues, and the vapours also make the waste furnace gases more harmful, so that, generally speaking, the use of fluorspar, except in conjunction with felspar and china clay as an opacifying agent, is not to be recommended.

J. H. D.

72. Sodium Bisulphate as a Substitute for Salt-cake in Glass Manufacture. L. SPRINGER (*Ker. Rundschau*, 1917, 25, 67).—The author discusses the differences between normal sodium sulphate (salt-cake) and sodium bisulphate from a glassmaker's point of view.

Theoretically, bisulphate could be used quite well as a substitute for salt-cake, since on heating it loses sulphuric acid and passes into the normal sulphate. Thus, if 240 parts of sodium bisulphate were used instead of 142 parts of salt-cake, the same amount of soda is introduced into the glass, and the results should be the same.

It is suggested that, in practice, the excessive quantity of sulphuric acid liberated from the bisulphate would attack the pots seriously, and also convert some of the lime or limespar into calcium sulphate, which is much more difficult to decompose. Further, if bisulphate is used, it is found necessary in practice to increase by 25 per cent. the amount of coke or reducing material added.

One sample of "bisulphate" analysed contained 94 per cent. of normal sodium sulphate, and consequently had a composition much more nearly approaching that of salt-cake than of bisulphate. One hundred parts of salt-cake could be substituted by 106 parts of this particular "bisulphate."

The author points out the danger of trusting too much to the name of a material, and emphasises the fact that in the use of substitute materials too much care cannot be given in obtaining exact information as to their composition.

J. H. D.

73. The Influence of Alumina on the Fusibility of Glasses. F. SINGER (*Ker. Rundschau*, 1917, 25, 142 *et seq.*).—A continuation of the author's previous work on the subject (*Ker. Rundschau*, 1915, 23; this *Journal*, 1917, 1, 16, A) and a reply to criticisms by F. Springer (*Ker. Rundschau*, 1915, 23, 272).

To prove that the addition of alumina actually does increase the fusibility of the glass, two series of experiments were made, starting from the following formulæ:—

Series I.: $0.5\text{Na}_2\text{O}$, 0.5CaO , 3SiO_2 .

Series II.: $0.4\text{Na}_2\text{O}$: 0.6CaO , 3SiO_2 .

Alumina was added in increasing quantities in each series, the amount rising from 0.05 to 0.2 mol. of alumina in steps of 0.05 molecule. Two separate sets of batches were made in each case, the alumina being introduced in the form of aluminium hydroxide and kaolin respectively, the other materials used being anhydrous carbonate of soda and limespar.

Three crucibles of each different glass were heated, and withdrawn at different temperatures, namely, S.K. 7, 12, and 16, in order to follow the progress of the melt. The results were as follows:—

- (1) The melts free from alumina were the most difficult to fuse.
- (2) The addition of alumina rendered the melt more fusible, and the effect was quite marked even with only 0.05 mol. Al_2O_3 .
- (3) Increasing additions of alumina caused a regularly increasing improvement in the fusibility of the batch.
- (4) No difference was observed between the aluminium hydroxide series and the kaolin series, so that it appears immaterial in what form the alumina is added.

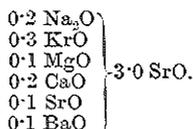
The author regards the production of glass as being a chemical action between the various materials used. This action begins at the surfaces or mutual points of contact of the various materials, and develops with the formation of various compounds or solid solutions which react upon each other and the still unattacked batch materials until the whole mass is free from solid particles. It is therefore immaterial whether the main batch constituent is sand or pegmatite (m. p. 1400°) so long as the composition of the glass is the same. The chief influences bearing upon the melting of the batch are, in the author's view, the fineness of the materials and the intimacy of their admixture.

In certain cases a considerable fritting of the materials was noticed at as low a temperature as 750° , and the author is of opinion that the reaction begins below 1000° in most cases.

Discussing the heat balance of the reactions concerned in the production of glass, Singer quotes tables (Mulert, *Zeitsch. anorg. Chem.*, 1912, 198) which show that the formation of all the common silicates met with in the process of glass manufacture is accompanied by a liberation of heat, that is, the reaction is endothermic (with the single exception of zinc orthosilicate). Thus, the combination of the various oxides used actually leads to the production of heat if this combination takes place so rapidly that the loss of heat by radiation does not more than counterbalance it. The increase in the fusibility of a glass in which alumina has been introduced in the form of felspar or pegmatite is not due, therefore, to the fact that in these minerals aluminium and alkali silicates are already formed, and consequently heat is unnecessary to effect their combination, but is due to the effect of the alumina itself. Pegmatite is a suitable means of adding alumina, since it is comparatively cheap, and also introduces some of the required alkali at the same time.

To determine whether alumina had a similar effect in the case

of more complex glasses, a glass was made of the following composition:—



and a glass of similar composition but with the addition of 0.15 mol. of alumina. In this case, also, the alumina-containing glass was the more fusible.

It does not follow from the experiments described that the effect of alumina would be the same in the case of different types of glass, *e.g.*, lead crystal, borate, or phosphate glasses, but it is probable that the results would only be different in degree. The limits for the beneficial use of alumina would, the author suggests, vary with each particular type of glass, and would probably be much lower with heavy lead glasses. Published researches dealing with the effect of alumina on pottery glazes are quoted at length and support the author's contention that alumina acts as a flux up to a certain limit. In the case of heavy lead glasses, a small quantity of alumina adds very considerably to the resistant qualities of the glass without having any very marked effect on its fusibility.

The effect of alumina on the limits of composition of good glasses according to the Tscheuschner formula is also discussed.

The conclusions may be summed up as follows:—It is possible simultaneously to improve the quality and to reduce the cost of production of glass by the introduction of suitable quantities of alumina, but it is not at present possible to put forward a theoretical scheme defining the exact quantity. The limits to the use of alumina in glasses of different composition are variable, and the amount that would be necessary and beneficial in one type of glass might be detrimental in another. In every case, however, the beneficial effects due to alumina increase up to a certain definite point with increasing additions of alumina, and this point can be definitely determined for any type of glass. Further increases of alumina beyond this limit are detrimental in all cases.

J. H. D.

74. A Deformation Study of $\text{MgO}-\text{Al}_2\text{O}_3-\text{SiO}_2$ Mixtures.

ARTHUR S. WATTS (*Trans. Amer. Cer. Soc.*, 1917, 19, 453).—This investigation was undertaken to ascertain whether it is possible to improve Bristol glaze, or lower its maturing temperature, or increase its range of adaptability by adding other aluminium silicates than those ordinarily employed without entering the field of bases belonging to the very soft glazes.

The object first sought was the determination of the most fusible mixture of $\text{MgO}-\text{Al}_2\text{O}_3-\text{SiO}_2$, using magnesium carbonate, kaolin, and flint as starting materials. The components were thoroughly mixed in plastic form to a state of homogeneity and made into cones of the same size as standard pyrometric cones. A little

dextrin was also added, as the mixtures high in magnesium carbonate are weak. The cones were placed in plaques containing about ten each; standard pyrometric cones and a recording pyrometer were used to check the temperature and the rate of temperature increase. The heating was conducted in a horizontal draught, gas-fired kiln equipped with a brick muffle to protect the test cones from direct contact with the flames and combustion gases. Experiments showed that the most fusible mixture is 20 per cent. MgO, 20 per cent. Al_2O_3 , 60 per cent. SiO_2 . The deformation temperature was cone 12 down, cone 13 not started.

The deformation process was very rapid.

A. M. J.

75. A Deformation Study of $\text{BaO-Al}_2\text{O}_3\text{-SiO}_2$ Mixtures.

ARTHUR S. WATTS (*Trans. Amer. Cer. Soc.*, 1917, 19, 457).—Continuing the search for those deformation eutectics which may enter into Bristol glazes, a series of mixtures was compounded of barium carbonate, kaolin, and flint.

The experiments were conducted as described in preceding abstract. Within the limits of the study made, it was found that there were two deformation eutectics: (a) 35 per cent. BaO, 10 per cent. Al_2O_3 , 55 per cent. SiO_2 ; (b) 40 per cent. BaO, 10 per cent. Al_2O_3 , 50 per cent. SiO_2 . Both deform completely at cone 6 down.

A. M. J.

76. Study of Three Component Normative Systems in Raw Lead Glazes.

W. G. WHITFORD (*Trans. Amer. Cer. Soc.*, 1917, 19, 312).—The use of *norms* in the calculation of glazes is an adaptation of the quantitative classification of the igneous rocks.

The basic idea of this classification is that the salts in solution in rock magmas may properly be considered to have the composition of those minerals which separate and crystallise when the magmas solidify. The *norm* of a rock magma is its standard mineral constitution as calculated by this method.

In regard to the *norm* constitution of glazes, it has never been claimed that these minerals are positively formed; it is simply a method of calculation based on the variation of groups rather than of single oxides, as is the case in the ordinary empirical formulæ. From the investigations made, the following general conclusions are drawn:—

1. With properly chosen end members, the normative system of glaze calculation and blending gives series of glazes the physical properties of which vary regularly.

2. Glazes made from blends of anorthite *norm* ($\text{CaO, Al}_2\text{O}_3, 2\text{SiO}_2$) with lead metasilicate *norm* (PbO, SiO_2) and orthoclase gave more refractory glazes than those made from wollastonite and zinc silicate. These blends gave also a large proportion of matt and semi-matt glazes.

3. Glazes made from blends of wollastonite *norm* (CaO, SiO_2) with lead metasilicate *norm* and orthoclase were mostly bright.

The few matts were of silky texture and had quite low alumina contents.

4. Glazes made from blends of zinc metasilicate *norm* (ZnO, SiO_2) with lead metasilicate *norm* and orthoclase were mostly bright glazes and stoneware enamels. A few matts and crystalline glazes were produced. A. M. J.

77. On the Absorption of Light in Coloured Glasses.
R. ZSIGMONDY (*Ann. Physik*, 1901, 4, 60).—It is known that the colour of a glass is dependent, not only on the nature of the colouring oxides, but also on the composition of the batch, and in many cases on the treatment of the glass. In this paper the author describes the nature of the absorptions of ten glasses of the following composition:—

No.	SiO ₂ . Per cent.	Na ₂ O. Per cent.	K ₂ O. Per cent.	CaO. Per cent.	ZnO. Per cent.	PbO. Per cent.	B ₂ O ₃ . Per cent.
1	74.5	25.4	—	—	—	—	—
2	65.7	—	34.3	—	—	—	—
3	71.8	14.8	—	13.4	—	—	—
4	66.7	—	20.9	12.4	—	—	—
5	51.4	10.6	—	—	—	38.0	—
6	48.7	—	15.2	—	—	36.0	—
7	67.6	13.9	—	—	18.25	—	—
9	—	30.7	—	—	—	—	69.3
11	—	—	—	—	—	—	100
15	20.0	—	—	—	—	80.0	—

A soda-borosilicate (No. 12) and a baryta-borosilicate (No. 14), the compositions of which are not given, were also examined.

To every 100 grams of batch made up as above an amount of each colouring agent was added either as oxide or as nitrate, the actual amounts calculated as oxides being as follows:—copper oxide, 2 grams; manganese oxide, 1.0 gram; iron oxide, 2.0 grams; cobalt oxide, 0.1 gram; uranium oxide, 2.0 grams; nickel oxide, 0.25 gram. For a chromium coloration, 1 gram of chromium oxide was added as chromic acid. The batches were melted in an oxidising fire.

The extinction coefficient was determined by a glass photometer for every glass. For wave-lengths of less than $450 \mu\mu$, Pulfrich's comparison spectroscope was sometimes used. The value $A = E/gS$ (where E is Bunsen's extinction coefficient, g is the number of milligrams of colouring oxide in 1 gram of the glass, and S is the specific gravity of the glass) was plotted against the wave-length.

Numerous simplifications, involving small errors, were introduced, owing to the large amount of work which had to be done. In spite of these errors, the measurements made have produced satisfactory curves.

Curves are given for the various types of glass and notes made on points of special interest. In the case of the cobalt glasses, it was found that those of the type $\text{R}'_2\text{O}, \text{R}''\text{O}, 5\text{SiO}_2$ had similar

absorption curves, glasses of other types showing somewhat different curves. It was assumed that the chromic acid introduced into the batch of the chromium glasses was all reduced to Cr_2O_3 . It is questionable whether this assumption is permissible, and on this account all the curves are not given. The uncertainty as to which oxide was present also decreased the value of the results with iron and manganese. A complete investigation of the colouring effect of the latter is regarded as desirable, owing to its use as a decoloriser. It has the general effect of absorbing the green, but the colour was found to vary greatly with the batch. The question of the oxide present is discussed at length. The absorption curves of the copper silicate glasses showed close agreement; glass No. 9 and the borosilicate No. 12 differed greatly. If the copper content of the blue silicate glasses is increased from 2 per cent. to from three to five times that value, green glasses of totally different absorptions are obtained. The curves for the nickel glasses show a great diversity, even the silicates exhibiting considerable differences among themselves.

In conclusion, attention is directed to the large differences in colouring power of the different oxides. J. R. C.

78. Coloured Glasses for Scientific and Technical Purposes. R. ZSIGMONDY (*Zeitsch. Instrumentenkunde*, 1901, 21, 97. Compare preceding abstract).—The durability of glass gives it an advantage over coloured liquids for light filters provided that the glass is optically homogeneous. The work here described was undertaken with the following objects:—(1) To provide a ray filter which should completely transmit one part of the spectrum, absorbing the remainder. (2) To obtain light filters for three-colour photography. (3) To find a suitable "smoked glass" which will absorb all parts of the spectrum equally. A Pulfrich comparison spectroscope was used.

Fourteen glasses were examined, and spectrum curves are given for them. Their absorptions from $\mu=0.70$ to $\mu=0.44$ were determined and the results tabulated. The compositions of the glasses are not stated. A glass transmitting only yellow could not be obtained, nor one which only absorbed yellowish-green. The difficulty of accurately reproducing a coloured glass, on account of the variation of the colour with the same batch, is referred to.

J. R. C.

79. On the Dependence of the Absorption of Light by Solids on the Temperature. J. KOENIGSBERGER (*Ann. Physik*, 1901, 4, 796).—The microphotometer referred to in Abs. No. 102 was specially designed for this investigation. Measurements were made at seven temperatures, ranging from 15° to 360° , the glass being heated in an air-bath at the higher temperature. Results are given for a heavy lead silicate glass (79 per cent. PbO), a lead silicate with 67.5 per cent. PbO and 3.0 per cent. potash, and for a "silver oxide" glass, the composition of which is not given. Two

specimens of the first type having different refractive indices were examined. Potassium bichromate was also studied, and the change of absorption with temperature found to be so large that temperatures between 100° and 200° could be ascertained by means of this variation to $\pm \frac{1}{3}^{\circ}$. An attempt was made to investigate the absorption of the red modification of selenium which occurs in ruby glass. Unfortunately, the surface changed so much on being heated that no definite results could be established. Other substances were also examined.

The following laws were established:—

“In solid, selectively absorbing bodies, ascending temperature effects a displacement of the absorption curve towards the region of greater wave-length, and in some cases simultaneously a small increase in the range of absorption. The magnitude of the maximum absorption apparently does not change.

“In the case of metals, the absorption remains unchanged throughout the interval $0-360^{\circ}$.”

The author states that the disagreement which they apparently exhibit from known phenomena can be explained. The first law is for non-metallic bodies, the second for metals. J. R. C.

80. The Anomalous Variation of the Longitudinal Elastic Modulus of some Glasses with Temperature, and the Influence of Steady Vibrations on the Elastic Modulus after Previous Heating. E. WANDERSLEB (*Ann. Physik*, 1902 **S**, 367).—The apparatus with which Winkelmann observed the anomalous change with temperature of Young's modulus for glass containing antimony was used. The method was only slightly modified. Several glasses were examined, of which six contained antimony. The author uses the term “normal condition” for the glass before heating, and when it had been heated he describes it as being in the labile or “accommodation” condition. He found the following differences between the two:—

(a) The value of Young's modulus in the normal condition E_n is 0.7 to 0.2 per cent. smaller than when in the accommodation condition. (b) Hooke's law is fulfilled in the normal condition to near the breaking point; in the accommodation condition, the ratio of the magnitude of the bending to the stress increased.

The variation of E with the temperature was only investigated with the six antimony glasses. Four of them were borosilicates containing 3, 3.5, 20, and 21 per cent. Sb_2O_3 ; the two others were free from boric acid and contained 10 and 15 per cent. Sb_2O_3 . The first four exhibited an increase of E with rising temperature, the other two behaving normally. Two theories are advanced to account for this difference.

The results can be represented by the expressions

$$E_t = E_{15} / \{1 - \alpha(t - 15) + \beta(t - 15)^2\}$$

and

$$E_t = E_{15} \{1 - \alpha(t - 15)\beta\}$$

for the anomalous and normal effects respectively, 15° being the

room temperature and α and β positive constants. The maxima of all four anomalous curves is at about 200° when E_t is 2 per cent. greater than E_{15} . For the normal glasses E_{200} is 2.1 per cent. smaller than E_{15} .

J. R. C.

81. The Influence of Temperature on the Thermal Conductivity of Glasses. J. KRUGER (*Ann. Physik*, 1901, 5, 919).—The results of the work by Paalhorn and by Focke on the thermal conductivity of identical glasses vary to the extent of 30 per cent. (Hovestadt's "Jena Glass," 1902, Everitt's trans., p. 212). In the investigation now described, the author, like Paalhorn, used, at first, Christiansen's method, although with some new corrections. By this method, however, it was found that different values of the temperature coefficient were obtained for the same glass when the layer of glycerine was renewed. The variations were not sufficient to explain the discrepancy between the results of the two observers, and a new method was accordingly employed. The same apparatus was used, but the temperature coefficient of the thermal conductivity was differently calculated. The following results were obtained:—

Glass Num- ber.	Percentage Composition of Glass.								Temp. coeff. $\times 10^{-6}$.
	SiO ₂ .	Na ₂ O.	K ₂ O.	ZnO.	CaO.	PbO.	As ₂ O ₅ .	Mn ₂ O ₄ .	
O 137	70.6	2.0	16.0	—	11.0	—	0.3	0.1	-(31 ± 15)
S 226	20.9	—	—	—	—	79.0	0.1	—	-34 ± 11
O 709	70.54	17.0	—	12.0	—	—	0.4	0.06	-45 ± 13

Finally, an explanation of the difference between Focke's and Paalhorn's values is advanced.

J. R. C.

82. Penetration of Glass by Electric Sparks and Rays. G. QUINCKE (*Ann. Physik*, 1915, 48, 113).—In this paper the author applies the theory of "foam walls" to the explanation of the effects produced when glass is penetrated by an electric spark.

The emanations from electric sparks and from metal wires which have been pulverised by the discharge current of a Leyden battery penetrate the glass, melt it, and spread out therein, like water in glue, and form with it oily liquids which solidify to foam walls of types I and II. Air particles and gas ions dragged by the emanations into the glass form thin air films in the cracks which arise when the foam walls and the contents of the enclosed foam chambers contract to a different extent on cooling. These air films assume the same shapes as films of viscous liquids in air. On both sides of the spark path the glass shows alternate positive and negative double refraction with optical axis perpendicular to the spark path. Sometimes spheres are formed with the polarisation colours of a positive spherocrystal of class II, as if they were expanded radially. With strong sparks, white, air-filled foam masses possessing both types of foam walls arise in the neighbourhood of the shortest electrical lines of force. Similar phenomena

originate in glass plates at the surface of which a platinum wire has been electrically pulverised.

If the air-filled cracks and the foam chambers enclosed by them are very small and invisible, a film of glass with a smaller retractive index than that of the original glass covers the surface. The quantity, surface tension, and shape of the solidified foam walls and cracks are determined by the quantity, quality, and velocity of the electrical emanations.

The shapes of the cracks are fully described and illustrated by many photomicrographs.

J. R. C.

83. Structure and Properties of Glass. G. QUINCKE (*Ann. Physik*, 1915, 46, 1025).—The cooling of glass is, according to the author's view, accompanied by the periodic separation, at short intervals, from a liquid A , of thin, invisible layers of oily liquids, B , B_1 , B_2 , rich in silicic acid. These liquids, A , B , B_1 , B_2 , are very viscous, the viscosity increasing with falling temperature. Each of them contains several allotropic modifications of silicic acid, having, in general, the same composition, but the concentrations vary in the different liquids. The quantities of these allotropic modifications, and the physical properties of the liquids, change with the previous history of the glass, with the initial and final temperatures, and with the duration and rapidity of heating and cooling. On account of the surface tension at the boundary of the oily liquids A and B , the films of the latter roll up, forming open or closed structures of many forms. These are "foam walls" of type I. They enclose "foam chambers" of type I, and gradually change to "foam walls" of type II. The greater the viscosity of the liquids A and B the slower this change takes place.

Glass may be regarded as a liquid jelly with invisible foam walls of liquid B , which enclose foam chambers filled with liquid A . The liquid jelly is changed into a solid jelly when A and B solidify. The smaller the foam chambers and the thinner the foam walls the slower this change takes place. At normal temperature, two pieces of glass flow together in the same way as two pieces of glue or red-hot iron.

The surface tension at the boundary of the liquids A and B is independent of the thickness of the layer of B if this is greater than 0.12μ , but if less the surface tension decreases with the thickness. The parts of the foam walls thinner than 0.12μ are absorbed by the thicker parts until only foam walls of this thickness or greater are left. The surface tension, the number of foam walls in unit volume, and the shapes of the foam walls of type I determine the solidity and durability of the glass. When glass is rolled, blown, or drawn out into rods and tubes, the surfaces between A and B are enlarged and the solidity increases, provided that the foam walls remain thicker than 0.12μ . If the glass is heated, the foam walls of type I rapidly change their shape or become again dissolved, once more separating on cooling.

If a film of liquid B_2 is stretched over B_1 , a hole in this film at

once contracts on account of its greater surface tension. In this way, foam walls covered with films of B_2 are more resisting to displacements, and therefore more durable. The greater the number of foam walls so covered the slower they change into type II and the longer the new glass takes to become aged. The thickness of these films may be less than one-millionth of a mm. The foam walls in new glass are probably less than 0.12μ . in thickness. Old glass has thicker foam walls, is not so readily cut, and shows a greater tendency to split.

Cracks appear in glass, spontaneously or by etching with boiling water or acids, on the surfaces of the thicker foam walls of B , which have changed their volume to a different extent from A , owing to thermal expansion, solidification, or swelling through the absorption of water. Large foam chambers and foam walls exhibit white foam masses of Réaumur's porcelain in the clear surrounding glass when this has been cooled very slowly in the pot.

In Aventurine glass, metallic copper crystals are formed with high temperatures, and are dissolved and disappear on cooling. They reappear on reheating, when B_1 changes with the increase of temperature, the lower modification of silicic acid passing into the higher. Copper oxide and gold in ruby glass are dissolved in the liquid B_1 and separate in ultra-microscopic particles on reheating. Colourless Aventurine glass shows copper crystals when exposed to sunlight, and colourless glass containing manganese becomes violet.

Glass, like liquid gelatine, becomes temporarily doubly refracting through expansion or compression. The double refraction and distortion disappear after a definite time—the "relaxation time." This may be a fraction of a second or years. It is small for small distortion, very big for large, lasting displacements of the smaller particles of the glass. The relaxation time, the fatigue, and the elastic and thermal after-effects depend on the size of the original displacements and the velocity with which it spreads from one point of the glass to the neighbouring layers, and on the distribution and thickness of the foam walls of the liquid B .

The paper is a continuation of previous work on the structure of solids, and is illustrated by a number of photomicrographs and diagrams of the phenomena described.

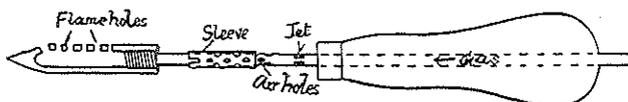
J. R. C.

III.—Lampworked and General Scientific Apparatus

84. A New Glass Cutting Tool. K. H. PARKER (*J. Amer. Chem. Soc.*, 1918, 40, 195).—The cutting of wide bore glass tube with a hot point of a file is a fairly common laboratory operation,

but in the case of very wide tube or more complicated apparatus it is difficult and uncertain. An improvement may be effected by having a point continually hot, and this can be obtained by having a tool consisting of a hollow head of brass or copper in which

FIG. 7.



ordinary gas can be burned. The supplies of gas and air should be adjusted so that the flame "strikes back" and burns within the head of the tool, thus keeping the point constantly red hot. With such a tool, it is possible to cut glass into almost any shape.

S. E.

85. Note upon Apparatus for the Determination of Boiling Points.

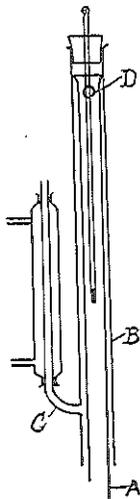
A. EDWARDS (*J. Soc. Chem. Ind.*, 1918, 37, 38).—In determining boiling points accurately, it is necessary to use the thermometers under the same conditions as those in which they were standardised, that is, with the whole of the mercury stem immersed in the hot vapour. A still-head has been designed so as to allow of such total immersion of the mercury thread, thus giving readings which can be corrected from the thermometer certificates without prior calculations for the differing stem immersions.

An inner tube (*A*) about 48 cm. long and 13 to 14 mm. wide is sealed at the top to an outer tube (*B*) of 16 to 17 mm. bore. Just below the seal the inner tube has a hole (*D*) blown through it. Near the bottom of the outer tube is the side-arm (*C*), which is water-jacketed and acts as a condenser. Wide-mouthed flasks are attached to *B*, and the vapour from them passes up *A*, over the thermometer stem, and through the hole at the top into the annular space between *A* and *B*. The vapour is condensed in *C*, and in returning to the flask seals up the annulus between *A* and *B*, thus compelling the vapour to pass in a steady stream up the inside of *A*.

The advantages claimed for this apparatus are (1) full immersion of the thermometer stem, (2) protection of inner current of vapour from draughts, (3) maintenance of a steady temperature, (4) return of the condensed liquid to the flask below the level of the thermometer bulb, and (5) avoidance of superheating.

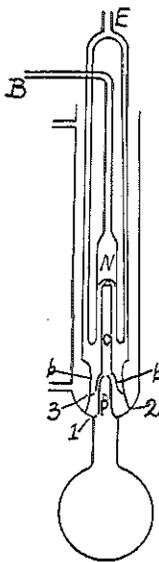
S. E.

FIG. 8.



86. An Improved High Vacuum Mercury Vapour Pump.

FIG. 9.



C. T. KNIPP (*Phys. Review*, 2nd Series, 1917, 9, 311).—The pump complete, except the usual mercury vapour trap, is shown in Fig. 9. The bulb to be exhausted and the mercury vapour trap are fused on to *B*, and the supporting pump is attached to *E*. The mercury vapour passes from the lower bulb, through the tubes *P* and *O*, to be deflected downwards by the umbrella *N* into the annular space, where it is condensed by the water-cooled surface of the enveloping tube. The gas which is drawn from *B* is forced downwards from the lower edge of *N*, and then removed by the lateral tubes *bb*, which give connection to the exhaust tube *E*. The condensed mercury collects at the ring seal 3, and slowly passes back to the flask through very small holes at 3 and 1, which act as valves and maintain a perfect seal. The short tube *P* is inserted to shield the hot mercury vapour from the cool surface at 3. The upper end of *P* telescopes into *O*, and the surface tension of the mercury condensing at the junction maintains a perfect seal.

It is claimed that the symmetrical design simplifies the glass-blowing, and that the pump is very speedy and effective in action.

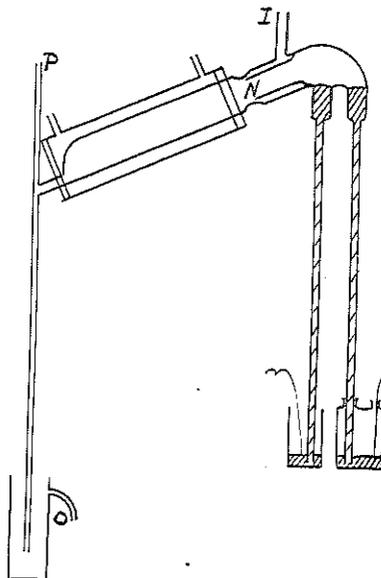
S. E.

87. A Mercury Arc Pump.**Exhaustion on the Current.**

L. T. JONES and H. O. RUSSELL (*Phys. Review*, 2nd Series, 1917, 10, 301).—This pump differs from that described by Knipp only in the manner of introducing, driving, and taking off the mercury. It permits of using the pump as a mercury still at the same time as it is being used for exhaustion purposes. Fig. 10 shows the arrangement. Two barometer columns introduce mercury into the arc, which is started by blowing into one of the Woulf's bottles. The mercury vapour is driven through the nozzle *N* and is condensed in the water-jacketed chamber, the condensed, clean mercury being drawn off at *O*. The vessel to be evacuated is attached to *I* and the supporting pump to *P*.

The Dependence of its Rate of

FIG. 10.



Danger of breakage, when the pump was made of ordinary glass, was only encountered at high current values. With a pump made of Pyrex glass, no difficulty in this respect was experienced. S. E.

88. The Estimation of Phenol in the Presence of the Three Cresols. The Knight Still-head. G. W. KNIGHT, C. T.

LINCOLN, G. FORMÁNEK, and H. L. FOLLETT (*J. Ind. Eng. Chem.*, 1918, 10, 9).—This still-head is specially designed for use in separating xylenols and higher homologues from phenol and the cresols. It consists of three 2-in. bulbs joined by glass tubes $\frac{3}{16}$ -in. long and $\frac{9}{32}$ -in. bore. The delivery arm is sealed in about $1\frac{1}{4}$ in. above the top bulb. The lower bulb has a glass syphon tube ($\frac{1}{8}$ -in. bore) joined near to the bottom of the bulb, and bent upwards to slightly less than half-way up the bulb, then returning and passing through and down the stem of the still-head. A piece of glass tube ($\frac{7}{32}$ -in. bore) is inserted between the stem and the bottom bulb so as to restrict the flow of the returning condensed liquid, and thus keep a layer in the bottom of the first bulb to act as a condenser for all vapours passing through it with a higher boiling point than the temperature of the liquid layer. When the height of this liquid layer reaches the level of the top of the syphon tube, it is automatically syphoned back to the distilling flask. S. E.

FIG. 11.

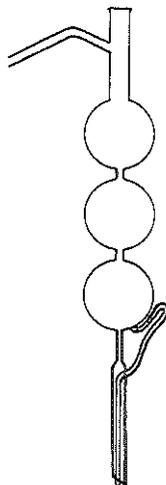
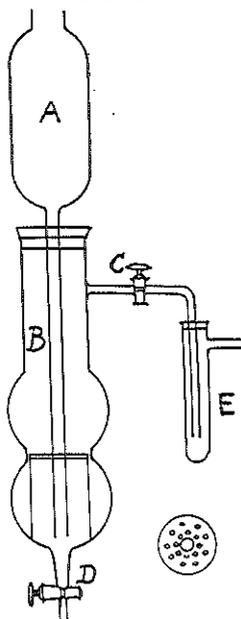


FIG. 12.



89. A New Portable Hydrogen Sulphide Generator. W. F. MUNN

(*J. Ind. Eng. Chem.*, 1918, 10, 130).—A fairly heavy glass tube, *B* (Fig. 12), which is the main part of the apparatus, has two bulbs blown near its lower end, and a stopcock, *D*, is sealed into the bottom of the end one. Near the top a side-arm with a stopcock, *C*, is sealed in and passes to a heavy walled test-tube, *E*. A lead plate with holes, as shown in the drawing, rests between the two bulbs on a piece of wide glass tube. The wide tube, *A*, with a long stem attached acts as the acid reservoir. Small lumps of iron sulphide are placed on the lead disc and the reservoir is filled with dilute sulphuric acid (1:8). By opening the cock, *D*, the acid which has been in contact with the sulphide and has become inactive may be removed without disturbing the apparatus or allowing any gas to escape. S. E.

90. Parallel Jet High Vacuum Pump. W. W. CRAWFORD (*Phys. Review*, 2nd Series, 1917, 10, 557).—In this pump there is used a specially designed jet, based on the principles of nozzle design in steam engineering practice. It is so arranged as to produce a stream of vapour in which the molecules are moving in parallel directions and with as nearly equal velocities as possible. With this type of pump no water cooling is necessary.

Apart from these two points the pump is not very dissimilar from that described by Langmuir (*Phys. Review*, 1916, 8, 48).

S. E.

91. A Simple and Efficient Filter Tube. W. M. THORNTON (*J. Ind. Eng. Chem.*, 1918, 10, 132).—This apparatus, which is very similar to the devices of Zöpfchen and of Bailey, has been designed for the filtering of precipitates which are so soluble as to necessitate the use of the least possible quantity of liquid for transferring and washing. A straight glass tube with a stopcock near the middle is sealed to a carbon filter tube which is fitted with a two-holed rubber stopper. The stem of a crucible holder passes through one hole and a tube leading to the suction pump passes through the other. A T-piece with rubber tube and a spring clip is inserted between the filter tube and the pump, so that when a precipitate has been transferred to the crucible and washed with a small quantity of water the pressure in the apparatus may be brought up to the normal by opening the clip, and the filtrate run out through the tap ready to be used for further washings.

S. E.

92. An Improved Automatic Pipette Washing Device. A. V. FULLER (*J. Ind. Eng. Chem.*, 1918, 10, 297).—A cylindrical metal tank is fitted with an inlet tube, and a syphon which empties it when full rather faster than the supply tube fills it. A gauze, standing on legs so as to be just above the level of the inlet and outlet holes, serves to carry the pipettes, which are placed open end downwards. A long brass wire is attached to the gauze to act as a lifter and thus facilitate the removal of the pipettes. Such an apparatus will hold a number of pipettes at once, and rinses both the inside and the outside at the same time.

S. E.

93. The Testing of Thermometers. W. SCHOESSER (*Zeitsch. Instrumentenkunde*, 1901, 21, 281).—An account is given of comparative tests on thermometers made of different kinds of glass. The errors were found to depend to a large extent on the chemical constitution of the glass, but the compositions are not stated. The mean of a number of thermometers of *verre dur* was found to agree very well with the readings of an air thermometer.

J. R. C.

94. Temperature Calibration of Glassware. W. A. WISSLER (*Met. Chem. Eng.*, 1917, 17, 452).—Standard solutions

prepared at one room temperature often have to be used at other room temperatures. The change in volume due to the variation in temperature alters the value of 1 c.c. in terms of the standard substance. To obviate this difficulty, the writer suggests the calibration of glass vessels at a standard temperature (say 20°) and, in addition, the marking of the apparatus with calibration marks to show the volumes which that amount of water would have at temperatures from 15° to 35°. J. D. C.

IV.—Decorated Glass.

V.—Optics and Optical Instruments.

95. Refraction through a Prism. F. G. SMITH (*Optician*, 1918, 55, 61).—The author gives another proof of Williams's construction (see this vol., Abs. 28). J. R. C.

96. The Change of the Optical Behaviour of different Glasses through Elastic Deformation. F. POCKELS (*Ann. Physik*, 1902, 7, 745).—Seven different glasses, of the following approximate compositions, were examined:—

Glass Num- ber.	Percentage Composition of Glass.							
	SiO ₂	B ₂ O ₃	PbO.	K ₂ O.	Na ₂ O.	Al ₂ O ₃	As ₂ O ₃	BaO.
S 205	—	69.1	—	—	8.0	18.0	0.2	4.7
O 428	—	56.0	32.0	—	—	12.0	—	—
O 658	32.75	31.0	25.0	3.0	1.0	7.0	0.25	—
O 2154	54.2	1.5	33.0	8.0	3.0	—	—	—
O 1571	41.0	—	51.7	7.0	—	—	0.3	—
O 500	29.3	—	67.5	3.0	—	—	0.2	—
S 57	18.0	—	82.0	—	—	—	—	—

A more detailed analysis is given of the last glass.

Test-pieces were prepared 20 × 7 × 5 mm. and were subjected to pressure applied parallel to the largest faces. The absolute retardation of the light polarised perpendicular to the direction of the pressure was observed, and the relative retardation of this and the wave polarised parallel to the pressure. The following conclusions were drawn:—

The double refraction produced by one-sided pressure is, as a rule, as hitherto assumed for glass in general, negative. With flint glasses of high lead content, however, it is positive, and there is

for every wave-length a lead silicate glass of definite constitution which is not made doubly refracting by pressure and consequent elastic deformation. The dispersion arising from the double refraction is principally very small, and can be positive or negative; it is only considerable with heavy flint glasses.

The variation of refractive index produced by hydrostatic pressure increases with the density and refractive index of the glass. The change is not governed by any formulæ which have been put forward to connect the index with the density. The temperature coefficient of the refractive index, when corrected for the influence of pressure, was calculated for glasses S 205, O 658, O 500, and S 57, and was found to have, for all of them, a positive value which increased rapidly with the lead content. The dispersion may increase or decrease as this "pure" temperature coefficient increases.

J. R. C.

97. The Change of Refracting Power of Heavy Flint Glass produced by Elastic Deformation. F. PÖCKELS (*Phys. Zeitsch.*, 1901, 2, 693).—A more complete consideration of the theory of the investigations already described. (Abs. No. 96.)

J. R. C.

98. Calculation of Telescope Objectives free from Chromatic and Spherical Aberration. S. D. CHALMERS (*Trans. Optical Soc.*, 1917, 18, 183).—An approximate expression for the various aberrations is deduced by neglecting the effects of thickness and the higher order aberrations. From these expressions, approximate curves are deduced and the various errors estimated. The approximate expressions are then used to calculate the changes in the curves necessary to correct these errors. The method is illustrated by a calculation of a doublet free from spherical aberration, chromatic aberration, and coma.

J. R. C.

99. Principles and Methods of Calculating Telescope Objectives. T. SMITH (*Trans. Optical Soc.*, 1917, 18, 160).—An account of the methods of calculation employed at the National Physical Laboratory in determining the curvature and radii of telescope objectives. Two methods are given, both different from that described by Everitt (this Journal, Abs., Vol. I., p. 113). The validity of the Gauss Laws is discussed, and the deviations caused by spherical aberrations and coma are considered. An example is given showing how the various aberrations are corrected.

J. R. C.

100. Prisms and their Errors. A. WHITWELL and T. CHAUNDY (*Optician*, 1918, 55, 51).—A mathematical treatment of the subject, which does not lend itself to abstraction. In the first article, the general principles are outlined and some propositions enunciated and proved dealing with the effects of multiple reflecting systems. In the succeeding papers these principles are employed

in the consideration of the behaviour of certain "standard" prisms. Roof edge prisms are next discussed and their optical properties analysed.

J. R. C.

101. A Method of Line Co-ordinates for Investigating the Aberrations of a Symmetrical Optical System. T. CHAUNDY (*Optician*, 1918, 54, 302, and 55, 3).—The application of line co-ordinates to the theory of geometrical optics is made by considering a typical ray of a beam of light passing through the optical system, and regarding that ray as completely determined by a knowledge of its six co-ordinates. The case considered was that of a symmetrical optical instrument composed of media bounded by spherical faces with collinear centres, in which only those rays are taken into account the inclination of which, θ , to the optical axis is small enough to require only the retention of low powers of θ . The discussion of this case is too mathematical to be abstracted.

J. R. C.

102. On Jena Light Filters. C. GREBE (*Zeitsch. Instrumentenkunde*, 1901, 21, 101).—The photographic results of Zsigmondy's work (Abs. No. 77) are described in this paper. Combinations suitable for three-colour photography are indicated. Thirty-five photographs are given.

J. R. C.

103. On the Absorption of Light in Solid Bodies. J. KOENIGSBERGER (*Zeitsch. Instrumentenkunde*, 1901, 21, 59. Abstracted from *Habilitationsschrift*, Freiburg, 1900).—The author describes a photometer with which the light absorbed by a plate of only $\frac{1}{4}$ sq. mm. cross-section can be measured. The arrangement consists essentially of a polarisation microscope, in front of the objective of which a calcspar plate and a double diaphragm are placed so that the extraordinary image of one opening adjoins the ordinary image of the other. A Savart's plate S is used, so that by rotation of a polarising prism two images of equal intensity polarised perpendicularly to one another are obtained. The plate of absorbing substance is placed in front of one of the diaphragms and the images equalised by a further rotation of the prism. This provides a measure of the absorption. The method is stated to be accurate to 0.15 per cent. Smoked glass wedges can be used to equalise the intensities if desired.

J. R. C.

104. A Microphotometer for Measuring the Absorption of Light. J. KOENIGSBERGER (*Zeitsch. Instrumentenkunde*, 1901, 21, 129).—The principle of this instrument is described in a previous paper (Abs. No. 103). It satisfies three photometric conditions:—(1) The accuracy of individual measurements is great. This is important when variations of temperature, pressure, and dissociation influence the absorption. (2) The absorption of very small portions of a substance can be determined. This is necessary when

the substance is not homogeneous. (3) The photometer is adaptable for light of any degree of homogeneity.

The two images overlap, and the intensities are equalised by observing the disappearance of the bands produced by a Savart's plate. Details of the construction of the various parts of the apparatus are given. The sensitiveness of the apparatus is due to the easy visibility of the bands. The variations of the readings in the blue and violet were larger than for other colours, whatever the intensity of the incident light. The author ascribes this to a physiological effect.

J. R. C.

105. A Spectrum Arrangement for a Microphotometer.

J. KOENIGSBERGER (*Zeitsch. Instrumentenkunde*, 1902, 22, 88).—In the photometer previously described (Abs. No. 103) a small direct-vision prism is placed between the analyser and telescope. The image of a scale is, by this means, thrown into the telescope so that the spectrum and the scale are viewed simultaneously. An arrangement is also described by which greater dispersion can be obtained.

J. R. C.

106. Photometric Apparatus. M. HERSCHKOWITSCH (*Zeitsch. Instrumentenkunde*, 1901, 21, 364).

—The principle of the photometer described is the same as that of the one designed by H. Krüss. Slightly increased accuracy is claimed for the instrument here described.

J. R. C.

107. Description of certain Optical Stores which have been Captured from the Enemy. A. C. WILLIAMS (*Trans. Optical Soc.*, 1917, 19, 53).

—Nearly all the instruments described are for use in connection with artillery. They include range-finders, directors for artillery, dial sights, clinometers, stereoscopic telescopes, binoculars, and periscopes. A full description is given in the original paper.

J. R. C.

108. The Theory of Two Lens Objectives. K. STREHL

(*Zeitsch. Instrumentenkunde*, 1901, 21, 10).—The lenses are supposed to be made of two fixed kinds of glass and to be infinitesimally thin. The paper is too mathematical to be abstracted.

J. R. C.

109. Testing Astronomical Objectives. H. LEHMANN

(*Zeitsch. Instrumentenkunde*, 1902, 22, 103).—The author has used Hartmann's method to test a large number of objectives, and has found that the fundamental errors can be determined with great accuracy. The correction of a lens can therefore be carried to a higher stage of refinement than by the usual tests. Curves are given illustrating the performance of lenses at different stages of correction.

J. R. C.

110. Application of Hartmann's Method of Zonal Testing to Astronomical Objectives. H. LEHMANN (*Zeitsch. Instru-*

mentenkunde, 1902, **22**, 325).—A continuation of the paper described in the previous abstract. Fuller details of the working of the method are given and its application to very fine measurements. The method is useful for testing plane parallel glasses and colour filters for homogeneity.
J. R. C.

111. Visual Images formed by Cylindrical and Astigmatic Lenses. J. D. VAN DER PLAATS (*Ann. Physik*, 1901, **5**, 772).—The author gives a short history of the development of lenses and describes the appearance of an object when viewed through a cylindrical lens. The theory of cylindrical lenses is considered, the thickness of the lens and chromatic aberration being neglected. The effect of spherical aberration in curving the image of a straight line is discussed. The same mathematical analysis is applied to astigmatic lenses.
J. R. C.

112. On the Image of a Plane formed by a Prism. R. STRAUBEL (*Ann. Physik*, 1902, **8**, 63).—A mathematical consideration of this subject, the plane being assumed small in comparison with its distance from the prism.
J. R. C.

113. An Elementary Explanation of Illumination in Optical Instruments. H. KRÜSS (*Zeitsch. Instrumentenkunde*, 1902, **22**, 254).—A simple analytical method is applied to the discussion of the brightness of the image seen in telescopes and microscopes. The percentage of light lost by reflection and absorption is calculated by this method.
J. R. C.

114. The Eye in Relation to Practical Lighting Problems. J. S. DOW (*Trans. Optical Soc.*, 1917, **18**, 215).—A brief account of a lecture on this subject given to the Optical Society. It was becoming increasingly recognised, the author stated, that the chief consideration in artificial illumination with the view of avoiding glare effects was to eliminate sudden transitions from brightness to darkness. The ratio of brightness which the eye can tolerate varies, but should not exceed 100:1. Nutting had suggested that, for general use, the best conditions were obtained by a mixture of 30 per cent. diffused and 70 per cent. direct light, as in normal daylight.
J. R. C.

115. A New Direct Vision Prism. W. VOLKMANN (*Ann. Physik*, 1902, **8**, 455).—The prism described is a pentagonal one, two of the faces being silvered to produce internal reflection. The optical effect is that of a prism of angle about 65 degrees.
J. R. C.

VI. Fuels, Refractories, and Furnaces.

116. Storage, Weathering, and Spontaneous Combustion of Coal. (*Met. Chem. Eng.*, 1917, 17, 481).—The matters to be considered in connection with storage of coal involve the question of losses due to weathering and those due to spontaneous ignition. A table is quoted from a publication of the Bureau of Mines showing the calorific value of four different kinds of coal (free from moisture, ash, and sulphur) before and after storage under different conditions. There was practically no loss in the samples stored under water, and in all tests the crushed coal deteriorated more rapidly than the *run-of-mine*. Heating and spontaneous combustion are caused by absorption of oxygen by both the organic and inorganic constituents, and are more active in coals exposing large surfaces. A pile of coal is a poor conductor, fires having been detected within a few feet of thermometers placed in the pile to check rise of temperature.

The oxidation of coal is continuous, and a number of processes are involved. For every coal a temperature exists below which oxidation is not ultimately destructive. It is between 200° and 275° for storage in air; above this temperature the oxidation does not depend on external conditions. Fire occurs beyond 350°. The temperature at which this autothigenous oxidation begins depends on several elements, (*a*) external sources of heat, (*b*) fineness of division, (*c*) presence of easily oxidisable compounds, (*d*) iron pyrites, (*e*) moisture, and (*f*) oxidation of carbon and hydrogen. The heating due to (*a*) may be eliminated by suitable storing, and that due to (*b*), which also facilitates (*c*), is avoidable to some extent. Sulphur in the form of iron pyrites is a source of heat due to the reaction between sulphur and oxygen. Here, again, rapidity of oxidation is dependent on the fineness of division, and the presence of dust is a source of danger. The instantaneous combustion of 1 per cent. sulphur in the coal is sufficient to raise the temperature of the mass 70°. In all the tests, the wetting of the coal increased the activity. The type of oxidation indicated by (*f*) does not appreciably take place at the ordinary temperature, but may be promoted by the other sources of heat. When this is the case, a large amount of heat is discharged and the process is very dangerous.

Preventives are suggested by the enumeration of the causes of spontaneous combustion. The avoidance of external heat and the elimination of coal dust are essentials. Dryness in storage nearly eliminates the oxidation of iron pyrites. Artificial treatment with chemicals does not offer great encouragement. Preliminary heating, effecting the initial stages of oxidation, or the submerging of coal, are preventive measures the industrial application of which have to be determined by experience.

For complete protection from spontaneous heating, the only

sure method is storage under water. Moisture in small quantities accelerates the absorption of oxygen, but submersion keeps the temperature low. However stored, it is advisable to use the storage pile for freshly mined deliveries, withdrawing from it for daily use. The depth of the pile depends on the nature of the coal, some authorities recommending a maximum of from 12 to 20 feet. Protection by ventilation has proved more dangerous than no protection. The Committee of the National Electric Light Association found no case on record of lump coal having suffered from spontaneous ignition. Finally, it is stated that constant vigilance is the only way by which loss can be guarded against. J. R. C.

117. On the Testing of Refractory Materials. J. W. MELLOR (*Trans. Cer. Soc.*, 1917, 17, 90).—The author believes that the standardisation of the methods of testing refractories is a duty of great importance; afterwards the specifications for refractories could be dealt with.

The ultimate object in testing a firebrick is to determine how it is likely to behave when in use. Fire stability is perhaps the most important quality, and one of the most important properties indicating the fire stability of a refractory is the squatting temperature. The softening temperature of a firebrick is not a definite, but rather a range of, temperature. Observation shows that this range of temperature is wider with aluminous than with siliceous firebricks.

If the temperature be rapidly raised, the material appears to soften at a higher temperature than if slowly heated, because the internal forces have not time to attain a state of equilibrium before the material is carried to a still higher temperature. Consequently, the rate of rise of temperature must be standardised if refractory tests are to be compared with one another. The softening temperature is determined by heating a selected piece of the refractory material, approximately shaped like a cone or prism $1\frac{1}{2}$ inches high and $\frac{1}{2}$ to $\frac{3}{4}$ inch base, alongside a suitable series of Seger cones. When the test-piece shows signs of fusion, it is assumed that the softening temperature is best represented in terms of the cone which squatted nearest to that at which the test-piece begins to fuse.

In the author's opinion it is better to express the softening temperature in terms of suitable cones rather than as a definite temperature determined by pyrometry, to carry out the softening test in a reducing atmosphere, and to use a small test-piece rather than a whole brick.

With regard to testing under load, in order to get comparable results from test to test for industrial purposes, it is necessary either to fix an arbitrary pressure for such tests or else to express the results in the form of a curve. With the more aluminous refractories there is a rapid fall in the squatting temperature as the load increases, and there does not appear to be a limit to the decrease in the refractoriness. Indeed, there is every reason to

suppose that aluminous bricks could be vitrified by pressure alone. The author discusses from a theoretical point of view the manufacture of firebricks without kiln-firing.

In the discussion which followed the paper, all speakers were in favour of the standardisation of tests and reports on refractories, and Mr. C. W. Thomas said that from the maker's point of view the tests should comprise:—

(1) Fusion point; (2) chemical analysis; (3) petrological analysis; (4) shrinkage at various furnace temperatures; (5) porosity; (6) plasticity; (7) resistance to load: (a) cold, (b) at various furnace temperatures; (8) resistance to various fluxes, as occurring in industrial furnaces; (9) resistance to abrasion; (10) behaviour in various gaseous atmospheres under furnace conditions.

Mr. Thomas discussed briefly each of the above points.

J. D. C.

118. The Clays of South Staffordshire and its Borders.

W. S. BOULTON (*Trans. Cer. Soc.*, 1916-17, 16, 237).—The clays are dealt with by the author in stratigraphical order, and within the limits of this district the rocks range from the Silurian to the Trias (if the Cambrian quartzite of the Lower Lickey Hills be excluded).

The subject is dealt with under the following sub-divisions:—Silurian; Coal-measures, with which are associated the fireclays; "Permian" marls or Keele beds; Keuper marls; glacial clays.

The district under discussion possesses refractory clays of world-renown and of high scientific interest, and a great variety of other clays, among them the raw material for some of the finest engineering bricks in the country.

Much valuable information is given by the author, and the paper is illustrated with diagrams.

C. M. M.

119. The Distribution and Geological Position of the Valuable Fireclays and Ganisters in the South of Scotland.

L. W. HINXMAN and M. MACGREGOR (*Trans. Cer. Soc.*, 1917, 17, 35).—The main subdivisions in the Carboniferous system recognised in Scotland are:—

Upper Barren Red Measures; Productive Coal-measures; Millstone Grit; Carboniferous Limestone Series; Calciferous Sandstone Series.

Fireclays occur in each of these subdivisions, but the chief source of valuable refractories in Scotland is the Millstone Grit. This is given priority by the authors, the fireclays and ganisters in the other subdivisions being dealt with more briefly.

The authors' survey shows that in Scotland there are vast resources of refractory clays, some as yet unworked, and that the main reserves of refractories are associated with rocks at or near the horizon of the Millstone Grit.

The paper is illustrated with diagrams and is full of valuable detail, which cannot be abstracted.

J. D. C.

120. The Refractory Properties of Silica. H. LE CHATELIER and B. BOGITCH (*Trans. Cer. Soc.*, 1917, 17, 10).—The use of silica bricks in the construction of furnaces has alone permitted the generalisation of firing with the regeneration of heat. Good mechanical resistance at high temperatures is a special peculiarity of silica bricks. It is not found in clay or magnesia bricks. The reason is that in all bricks the basic oxides foreign to the principal refractory material produce a fusible matter towards 1200°. In the case of magnesia, the solid grains float in the melted magma and slip easily over one another, as wet sand would do. Silica, however, in well-fired bricks, forms a continuous network in the pores of which the melted mass lodges without diminishing the mechanical resistance. The network is formed by the quartz, unstable at high temperatures, dissolving in the melted magma and recrystallising first of all as cristobalite, then as tridymite. This recrystallisation of silica, and subsequently the formation of the permanent network, requires firing, sufficiently prolonged, at a suitable temperature. Bricks little fired, the network of which is not yet formed, are composed of grains of quartz floating in the melted mass, and are plastic and useless.

When a good silica brick is heated, its resistance diminishes with rise of temperature. This is due to the solubility of silica increasing with the temperature and causing a progressive dissolution of the crystalline network, tending to disintegrate it and even to dislocate it entirely. This effect is the more delayed as the network is better developed.

The authors' researches on the study of the rigidity of the network dealt with the following factors:—

(1) *The Proportion of Fluxes.*—Analytical results show that good bricks contain from 3 to 5 per cent. of basic oxides.

(2) *The Actual Temperature which a Brick can Support.*—The bricks must be manufactured with the view of satisfying temperature requirements. The higher the temperature, the less the amount of flux which must be added.

(3) *The Good Formation of the Network.*—In order to develop the network, the brick must be kept for a very long time at such a high temperature that the melted magma may be sufficiently fluid. Experience seems to indicate that several days' firing at 1450° is necessary.

(4) *The Disintegration of the Network.*—Cracks and spalling are caused by rapid heating of a badly-fired brick, due to the expansion of unchanged quartz grains.

All good bricks possess at 1600°, after heating for one hour, a resistance to crushing at least equal to 10 kil. per sq. cm.

In the discussion which followed the reading of the paper, the cost, and the question of the necessity, of firing bricks until all the quartz had been changed into tridymite was debated. Mr. G. W. Mottram raised the question of the use of amorphous silica and of angularly-grained silica. He reported the successful working of some silica bricks made from round sand grains. J. D. C.

121. The Estimation of the Proportions of Quartz, Tridymite, etc., in Silica Bricks. A. SCOTT (*Trans. Cer. Soc.*, 1917, 17, 188).—For this estimation, chemical analysis is not available, and specific gravity measurements cannot be used with impure materials. Direct measurement with the microscope, however, provides a comparatively rapid and accurate method, and can be carried out with no apparatus beyond a microscope and thin sections of the materials.

The method is difficult to apply to the estimation of all the constituents of silica bricks, owing to the fineness of grain of the tridymite and cristobalite, but it gives excellent results for the estimation of the proportion of unchanged quartz.

The thin section, mounted on a slide, is best placed between crossed Nicols, as the quartz can then be distinguished by its interference colour, generally yellow. A series of lines (6 to 8) is drawn on the slide parallel to one edge and a second series perpendicular to the first. The slide is then adjusted so that one line coincides with one of the cross-wires of the eyepiece, and the whole of the section along that line is made to traverse the field of view and the length of intercept of each quartz crystal measured. The measurement may be done by means of a micrometer eyepiece, but after a little practice good results can be obtained by dividing the cross-wire into ten parts 'by eye' and estimating the intercept of each crystal in terms of these 'tenths' as units. The total intercept of the section along the line is measured in the same units, occasional holes being allowed for. The same procedure is carried out along the other lines parallel to the above, and also in a perpendicular direction along the second set of lines. The intercepts made by the quartz crystals are then added together and divided by the sum of the intercepts made by the section along the two sets of lines, and the percentage of quartz by volume is obtained.

In order that the results shall have a probable error of not more than 1 per cent., it is advisable to measure intercepts totalling about 1,500 units.

J. D. C.

122. The Inversions in Silica Bricks. A. SCOTT (*Trans. Cer. Soc.*, 1917, 17, 137).—The method employed in studying the inversions was the microscopic examination of thin sections of unused bricks and of other samples of the same batch (where possible) which had been subjected to temperatures varying from 1000° to 1600°. In preparing the thin sections, the 'chip' was treated to a preliminary heating in Canada balsam, and the usual difficulty due to friability was thus overcome. The sections used had a thickness of the order of 0.03 mm.

The conclusions drawn were as follows. During the kiln firing the bond reacts with some of the silica to form silicates, which generally cool as glass, though they occasionally are partly crystalline, and the quartz grains of the matrix are partly converted to cristobalite. During use at high temperatures, the quartz of the fragments is gradually converted to cristobalite, while the

crystalite of the matrix is transformed simply to twinned tridymite. Finally, the rock fragments are completely converted to tridymite, which is usually of the pseudo-hexagonal form.

The author discusses volume changes and the function of the flux in these transitions and the stability relations of the different forms of silica.

The paper is illustrated by photomicrographs. J. D. C.

123. Volume Changes of some Commercial Silica Bricks on Heating. D. W. Ross (*Trans. Amer. Cer. Soc.*, 1917, 19, 83).—If a silica brick has been burned only to a slight degree, a large proportion of its material remains as unaltered quartz, which when reheated develops undue permanent expansion and would tend to weaken any furnace into which it was built.

If, on the other hand, a brick has been slowly burned (to allow thorough bonding) to an advanced degree, much of the material will have been inverted into cristobalite and tridymite, in which case additional heatings will not develop further permanent expansion.

The volume increase per cent. on reheating may therefore be taken as a measure of the previous degree of burning of the silica brick. To obtain accurate results, it is advisable to give the bricks repeated burnings to any one temperature until approximate equilibrium is reached, that is, until the reheating causes no further increase in volume.

In some cases on reheating there is a tendency for the particles to fuse and draw closer together, but this is only apparent in certain cases of well-burned brick, and is therefore of minor importance.

The specific gravity of raw quartzite or crystalline quartz and flint (according to J. W. Mellor, *Trans. Eng. Cer. Soc.*, 15, 77) ranges from 2.59 to 2.66, that of artificial tridymite and cristobalite 2.270 to 2.333, and therefore the specific gravity of a silica brick should again designate clearly the degree to which silica brick has been burned. Experiments show that this is the case.

Changes in specific gravity on successive heatings will indicate the rate at which any given silica brick approaches equilibrium. A combination of the volume and specific gravity methods should therefore afford means of determining accurately whether or not silica refractories have been fired to the proper temperature, and thus of fixing the quality of the material.

These methods were applied by the author to test some silica bricks of American manufacture. A. M. J.

124. An Examination of the After-contraction or After-expansion of Firebricks in Oxidising and Reducing Atmospheres. J. W. MELLOR (*Trans. Cer. Soc.*, 1916-17, 16, 268).—From the author's measurements, the conclusion is drawn that silica bricks show a general tendency to exhibit a smaller expansion in a reducing than in an oxidising atmosphere and, for

(fireclay) firebricks, to give a greater contraction in a reducing than in an oxidising atmosphere. This result might have been anticipated, because it is in agreement with the much greater fluxing effect of "iron" in a reducing than in an oxidising atmosphere.

The magnitude of the fluxing effect induced by the reducing atmosphere depends, among other factors, upon the strength of the reducing atmosphere, *i.e.*, on the proportion (and kind) of reducing gases present; also upon the rate the gases penetrate into the interior of the brick, which depends upon the character of the superficial skin and the porosity of the brick. Further, it depends on the temperature and time the brick is bathed in the reducing atmosphere. Hence it is difficult to get comparable results with the contraction test under reducing conditions.

It is expected that further experiments on this subject will be made; meanwhile, it is recommended that the "contraction test" be conducted in as nearly a neutral atmosphere as practicable.

C. M. M.

125. The Hot and Cold Sizes of Firebricks. J. W. MELLOR (*Trans. Cer. Soc.*, 1916—17, 16, 270).—A series of experiments was made to get an idea of the difference between the hot and cold size of typical firebricks as they occur on the market. The measurements on the whole brick were made with Coppée's apparatus.

It was found that if the brick is imperfectly burned, there is superposed on the effects of thermal expansion an after-contraction or after-expansion. In consequence, in the former case, the results are too small, and in the latter too large. Further, the brick does not contract to its original volume on cooling; also, in all cases of after-contraction (or, *mutatis mutandis*, after-expansion) the brick may show a smaller volume at, say, 1180°, than it does at, say, 1060°. This shows that the effects of thermal expansion are altogether masked by the after-contraction.

These measurements also show that the coefficient of expansion of fireclays and of silica bricks decreases with rise of temperature.

C. M. M.

126. The Spalling of Magnesite Bricks. J. W. MELLOR (*Trans. Cer. Soc.*, 1916—17, 16, 85).—The valuable refractory qualities of magnesite bricks are seriously impaired by the objectionable way in which the bricks crack, flake, and spall at high temperatures.

Magnesia from calcined magnesite occurs in two different forms which may be called α - and β -magnesia. The former has a lower specific gravity, 3.2, and is more chemically active than β -magnesia, which has a higher specific gravity of nearly 3.7.

There are two important primary causes of the spalling of magnesite bricks:—(i) The shrinkage caused by the change of calcined magnesite from the α - to the β -variety. The obvious cure is to shrink the magnesite as completely as possible before the bricks are put on the market. (ii) The shrinkage caused by the

closing of the pores. The obvious remedy is to keep the porosity as low as possible.

The strains set by a sudden chilling of the hot furnace may aggravate spalling primarily produced when bricks are made with too high a porosity from imperfectly shrunk magnesia. If the bricks are made with too low a porosity, they would probably be more inclined to crack or dunt by abrupt changes of temperature.

The author states that it should be possible to determine by preliminary tests whether a magnesite brick is likely to spall seriously or not, and the manufacturer ought to be able to obtain definite objectives in order to reduce spalling to a minimum. C. M. M.

127. A Curious Mineral occurring in a Magnesia Brick.

H. B. CRONSHAW (*Trans. Cer. Soc.*, 1916-17, 16, 101).—A short paper recording some preliminary investigations into the nature of a very curious and highly interesting mineral occurring in a used magnesia brick of a somewhat ferruginous nature.

As is generally the case with magnesia bricks, the groundwork was markedly porous, and a casual examination sufficed to identify both the ferruginous magnesia and the colourless mineral of the grog particles. The feature of especial interest, however, was the occurrence of somewhat sparsely distributed and ill-formed crystals, which stand out in bold relief, and possess a rich brownish-red colour. Some of the crystals were traversed by a rectangular system of cleavage cracks, but all agreed in being distinctly isotropic. These features together with other characteristics suggested minerals like ruby or magnesia, spinel, chromite, perovskite, magnesioferrite, and others.

From a sample reduced to powder, these particles were isolated by means of a magnetised needle, some particles being more strongly attracted than others. Again, the crystals were found to be immune from the attack of strong hydrochloric acid, but a solution was quickly effected in strong nitric acid, when it was found that magnesium was present.

This unknown mineral seems to agree in composition with the mineral magnesioferrite, MgO, Fe_2O_3 , but so far magnesioferrite has not been recorded as occurring under these conditions. Finally, there is a possibility of mixed crystals of MgO and MgO, Fe_2O_3 .

C. M. M.

128. Black Cores in Fireclay Goods. J. W. MELLOR (*Trans. Cer. Soc.*, 1916-17, 16, 259).

—Black coring may be regarded as a disease which affects bricks of different kinds, and is produced by unhealthy conditions which obtain during firing. Analyses of black cores show that in some cases much carbon is present; in others there is virtually no carbon, but a comparatively large proportion of the contained iron is present in the ferrous condition; and in a third case, both ferrous iron and carbon are present. There are all possible gradations between these types. So far as mere composition of the clay is concerned, there are therefore two conditions,

namely, the presence of iron and carbon, either or both of which may favour the production of a black core.

The carbon in clays may occur in a form closely allied to bituminous coal or to anthracite coal, whilst in others the carbonaceous matter consists of partially decayed vegetable tissue. Again, there are all possible gradations between these three types. The carbon in the clay begins to burn out slowly as soon as the kiln has attained a dull red heat. Vegetable tissue gives no particular trouble; anthracite carbon burns out without difficulty, but bituminous carbon is a source of danger, because it gives off a combustible gas, which, if much be present, will burn at the surface of the clay.

The critical stage, therefore, in the firing of a brick made from a clay containing much carbonaceous matter is the oxidation period, and it is most important to get rid of all such matter before contraction of the brick has progressed to any marked degree. The most favourable temperature for the burning of the carbon is between 600° and 900°, the higher temperature giving the faster rate of oxidation.

If iron is present in the interior of a brick the air will attack it, converting the ferrous into the ferric condition. Ferrous iron heated just above 1000° in contact with clay forms a fusible mass, whilst ferric iron does not begin to fuse till well above 1500°; so that ferric iron in clays may be regarded as a refractory material when heated in an oxidising atmosphere. Black cores will begin to fuse and form a slag if some carbon remains unoxidised in the presence of ferrous iron. This slagging is most pronounced with the more ferruginous clays.

Bricks in badly ventilated parts are quite likely to have black cores; hence if the steam given off from the bricks lags in the kiln in the vicinity of the bricks it will act as a barrage or buffer between the bricks and the outside air. Therefore that mode of setting bricks in the kiln which ensures the best circulation of air will be least favourable to black coring.

Variations in the mode of manufacture, or materials which make it more difficult for the air to circulate in the interior of the bricks, will develop black cores. For example, the finer the grain the more persistent the black core, and, conversely, any mode of manufacture which gives an open, porous body will hinder the development of a black core.

C. M. M.

129. Fusion Point and Composition of Refractory Clays.

R. J. MONTGOMERY and C. E. FULTON (*Trans. Amer. Cer. Soc.*, 1917, 19, 303).—By plotting the results with reference to the silica-alumina fusibility, the authors have made it evident that the silica-alumina ratio is the determining factor of fundamental importance in deciding the limit of refractoriness of a clay. The following conclusions may be drawn from their work:—

1. The silica-alumina eutectic curve limits the refractoriness of a clay.

2. The fall in temperature (measured in S.K.) below this eutectic line depends primarily upon the percentage of flux present.
3. As the amount of flux increases its activity increases rapidly.
4. About 14 to 18 per cent. alumina (based on alumina + silica = 100) will give the maximum activity of the fluxes present.
5. With high silica beyond the eutectic point, the activity of the fluxes decreases rapidly.

A. M. J.

130. The Advantages of Clay Storage. F. H. RIDDLE (*Trans. Amer. Cer. Soc.*, 1917, 19, 103).—When clay is stored, portions from different parts of the banks may be mixed so as to obtain a material of more uniform character and capable of being more systematically handled during manufacture.

A clay which weathers with storing will, as a rule, behave much better in grinding and in manufacturing as a result of storage.

Weathering tends to bring about a differentiation in sizing during grinding, to produce greater plasticity, and to dissolve and wash out soluble salts which produce objectionable scumming.

If it is desired to weather the clay more rapidly than ordinary exposure to air would do, steam supply pipes may be laid along the ground under the clay.

A detailed description is given of a successful clay storage installation.

A. M. J.

131. The Relation of Salt to Clay in the Purification of Clays. H. G. SCHURCHT (*Trans. Amer. Cer. Soc.*, 1917, 19, 460).—The paper deals with the effect of alkalies on clay suspensions (slips).

When certain alkaline salts are added to clay slips in small quantities, the slips become liquefied and the fine clay particles remain in suspension, while the coarser particles settle to the bottom.

The separation takes place to some extent when no alkalies are used, but, in this case, a large percentage of fine clay is carried down mechanically with the coarser particles. The use of alkalies renders possible a sharper separation between the coarse impurities and the fine clay substance.

This is accounted for on the electrolytic theory by the fact that the negatively charged ions of the electrolyte repel the similarly charged clay particles, and so cause an apparent liquefaction.

When the electrolyte is added beyond a certain amount, a re-thickening of the slip takes place.

Acids and most acid salts cause a thickening or flocculation when added to clay slips.

The following conclusions have been drawn as to the relation between the concentration of alkalies necessary to produce minimum viscosity in the clay slips and the concentration of clay in the same. The constancy of the ratio of electrolyte to clay is much more important in maintaining minimum viscosity in clay slips than that of the ratio of electrolyte to water, although the chemical

activity of the electrolyte on clay may be slightly less in more concentrated than in dilute solutions.

Small quantities of sodium hydroxide cause the decrease in viscosity to be retarded up to a certain point, and then when more is added there is a sudden drop to minimum viscosity. The limits in which sodium hydroxide produces minimum viscosity are therefore small, whilst the limits in which sodium silicate and sodium carbonate produce minimum viscosity are relatively large, for with the two latter the decrease in viscosity is not retarded. The viscosity data would indicate that 50—58 per cent. more clay could be treated when alkali sufficient to produce minimum viscosity is added than when none is present.

Confirmation of this conclusion on a commercial scale is still required. A. M. J.

132. The Use of Sulphuric Acid in the Sedimentation of Kaolins. H. G. SCHURECHT (*Trans. Amer. Cer. Soc.*, 1917, 19, 130).—The amount of sulphuric acid employed for neutralising the alkali used in the purification of kaolins should be less than the equivalent of alkali, but should vary with different clays.

An excess of acid increases the viscosity, and consequently the plasticity, of the clay slip over its original value, whilst it may cause a black scum to appear on the kaolin on drying.

Experiments show that kaolins deflocculated by alkalies could not be filtered, as the fine particles pass through the filter to a small extent and also clog it up. When the kaolin is partly neutralised by adding sulphuric acid to the slip it can be filtered readily. The rate of disintegration in water is much slower for deflocculated than for untreated kaolin. A. M. J.

133. The Burning Properties of some American Refractory Clays. H. G. SCHURECHT (*Trans. Amer. Cer. Soc.*, 1917, 19, 248).—The author noticed in testing fireclays that the load-carrying capacity of clays at furnace temperatures was increased remarkably by burning the fireclays to higher temperatures.

The burning and shrinkage behaviour of the clays were studied by firing test-pieces, 2 × 1 × 1 inches, at the rate of about 20° per hour.

The porosities were determined by weighing the pieces dry, saturated with water, and finally suspended in water.

The apparent porosity = $\frac{W - D}{W - S} \times 100$, where W = weight of saturated briquette, D = weight of dry briquette, S = weight of saturated briquette suspended in water. The volume shrinkages were calculated in terms of dry volume.

For the burning test, the pieces were 7 × 1 × 1 inches, and they were fired at intervals between 1210° and 1410°.

The test pieces were supported 6 inches apart on fireclay knife-edges, and the weight, which was of fireclay (3 lb. for pieces having an inch cross-section), was applied in the middle.

In all cases the load-carrying capacity at furnace temperatures was improved by burning the clay to a higher temperature. Open burning clays are most improved, while the closer burning clays, which vitrify at lower temperatures, show some improvement. The fire-shrinkage is, in some cases, reduced by burning the clay to as high a temperature as possible.

One of the factors causing an improvement is undoubtedly the refractoriness of the fused portion of the clay, which gives the clay strength at furnace temperatures.

A. M. J.

134. The Effect of the Size of Grog in Fireclay Bodies.

F. A. KIRKPATRICK (*Trans. Amer. Cer. Soc.*, 1917, 19, 268).—In order to obtain fireclay bodies having the highest moduli of rupture in the raw, dried state, two conditions are necessary:—

(1) The grog must not be so large that it forms cracks on planes of weakness.

(2) The grog must be so proportioned that the smaller sizes fill the voids between the larger particles, giving maximum density and strength.

The grog portions of the strongest bodies were found to have the following limits of composition:—

25 to 66.6 per cent., of 20—40 grog.

0 to 25 per cent., of 40—80 grog.

33.3 to 66.6 per cent., of 80 dust.

Grog for glass pots and similar bodies may contain too much fine or intermediate sized material, causing low strength and cracking in drying.

Triaxial diagrams are given showing how 20-mesh grog may be corrected to give maximum strength.

Where screening into separate sizes and recombining is uneconomical, the desired conditions may be obtained by control of time of grinding, size of openings in screen plates, pressure, etc. In American practice the grog for saggars is all passed through 3- to 6-mesh screens. German and French manufacturers separate the grog into three sizes, classified roughly as fine, medium, and coarse, and then use widely varying proportions of each size. In general, the larger the sagger the larger are the sizes of grog used.

Experiments carried out during this investigation show that both very large and very fine grog are undesirable in sagger bodies. Considering the size of grog as the governing factor, the best sizes for saggars of 1 inch sides and bottoms proved to be 4—80 grog in proper proportions.

Tables and triaxial diagrams are given showing the relation between composition and strength and resistance to repeated heating and cooling.

A. M. J.

135. Marquardt Porcelain.

F. H. RIDDLE (*Trans. Amer. Cer. Soc.*, 1917, 19, 397).—The manufacture of Marquardt porcelain is now being carried on on a commercial basis in the United States.

The composition was based on the analysis of a sand-blasted

Marquardt tube, and contains four different clays and two different grogs (the compositions are given). Each grog mixture is ground dry, mixed into a thick paste with water, moulded by hand into balls, dried, and calcined.

The body part is carefully blunged, filtered, and pressed. The whole is then thoroughly pugged and brought to a suitable state of viscosity.

The smaller tubes are pressed on a miniature hydraulic press and the larger tubes cast.

For burning, the tubes are set in special saggars and hung from the heads by the use of universal swinging rings. The temperature of cone 1 or above is sufficient temperature for the biscuit oven. The glost oven temperature was found to depend upon the melting point of the glaze, but should not be below cone 16.

The best type of glaze is found to be a high whiting matt glaze of the formula $\text{CaO}, \text{Al}_2\text{O}_3, 4\text{SiO}_2$, maturing at cone 17.

A. M. J.

136. Magnesium Aluminate (Spinel). F. H. RIDDLE (*Trans. Amer. Cer. Soc.*, 1917, 19, 404).—Tubes and crucibles of *spinel* were, for some time, supplied by the Royal Porcelain Manufactory, Berlin.

Spinel has the formula $\text{MgO}, \text{Al}_2\text{O}_3$, containing MgO 28.4 per cent., Al_2O_3 71.6 per cent., and its fusion temperature is $2135^\circ \pm 20^\circ$.

To obtain similar ware, a mixture of 45.2 per cent. of flocculent magnesium carbonate and 54.8 of calcined alumina was ground dry in a ball mill, tempered with water, and made into balls about $1\frac{1}{4}$ inches in diameter.

On burning there is considerable shrinkage, so that the higher the burning temperature and the longer it is maintained the better is the result.

After calcining, the material was ground dry in a mortar.

When mixed with water the substance has no plasticity; ground sand or glass mixed with water is about as easy to work. Casting was tried with all mixtures and in several ways, but there were always great difficulties.

Jigging was then tried, and has worked very well. The water-content must be correctly adjusted and the moulds coated with a mixture of very fine graphite suspended in oil.

The ware burned at cone 17 was cream-white, porous, and appeared similar to an ordinary white biscuit body. The ware burned to cone 35 was vitrified to a dense, translucent body. Examination of a broken section showed that the vitrification had proceeded so far that the grains had lost their identity, at least to the naked eye. *Spinel* crucibles show that the material is not easily attacked either by molten slag or iron so long as the exposed surfaces are dense and free from blemishes.

The crucibles will withstand ordinary usage, but not rapid cooling.

A. M. J.

137. Method of Temperature Control in Glass-melting Furnaces. C. N. FENNER (*Phys. Rev.*, 1918, 11, 141). The author describes an investigation of the method of regulating furnace temperatures in the glass-making plant of the Bausch and Lomb Optical Company. Originally thermoelements of platinum-platinum rhodium were introduced through the furnace walls and led to a direct reader conveniently placed for observation by the furnacemen. This proved unsatisfactory, owing, it was thought, to contamination of the thermoelements by furnace gases. A Leeds and Northrup optical pyrometer was therefore tried, and preliminary experiments were made to ascertain if the radiation given out by the furnace walls corresponded with black-body radiation, that is, whether or not the temperature indicated was the true temperature. This test was made by introducing into the furnace a special porcelain tube containing a thermo-junction, and comparing the temperature thus obtained with that given by the optical pyrometer. At the temperatures at which the important operations of glass-making are carried out (1300—1400°), the two instruments agreed almost exactly. The optical pyrometer has therefore been adopted, and the resulting increased preciseness of temperature control has solved many of the difficulties previously encountered.

J. W. T. W.

138. Standardisation of Base-metal Thermo-couples. P. D. FOOTE, T. R. HARRISON, and C. O. FAIRCCHILD (*Met. Chem. Eng.*, 1918, 18, 403).—A form of furnace suitable for the rapid testing of a large number of couples, consisting essentially of a tube of nickel or nickel-chromium alloy, is described. A furnace of this type may be heated very rapidly up to a temperature of 1100°, and the couples may be calibrated by comparison with a standard couple at five or six different temperatures in half-an-hour. Another method is to put the couples into a muffle furnace, but calibration in this way only gives results accurate to 20°. The most satisfactory method for calibrating base-metal couples on a large scale is by use of a bath of molten metal. Tin is very suitable in the range 300° to 1000° on account of its low volatility. For some types of base-metal couple the curve is slightly S-shaped showing small inflections near the critical points of the metals of which the couple is constructed. The calibration must be made at short temperature intervals in these regions. Sometimes a base-metal thermo-couple is checked by comparing the *E.M.F.* at a single point with that given by the calibration data. The melting point of common salt (801°) is a convenient standard temperature, and the couples can be immersed in a bath of this substance unprotected.

When a thermo-couple in a furnace is connected to an indicating instrument, the potential difference between the terminals of the instrument will not be the same as the *E.M.F.* of the couple, owing to the resistance of the leads. This may introduce an error of 17 per cent., which is compensated for by graduating the scale of

the instrument to read the *E.M.F.* when couple and leads have a definite resistance. Bad contacts, deterioration of the couple due to oxidation, change in the depth of immersion, and so on, will alter the resistance of this external circuit. The error resulting from such a change is much decreased by using an indicator of high resistance, for example, 300 ohms or more.

Usually, indicators are graduated to read temperatures directly, and must be used with the type of couple for which the scale was designed. It is frequently desirable to check the readings of a thermo-couple without removing it from the furnace in which it is installed. The ordinary calibration of a base-metal couple in the laboratory does not hold when the couple is returned to its original installation. This is on account of the heterogeneity developed in a base-metal couple after prolonged heating. If a homogeneity test were applied it would indicate that the pyrometer should be thrown away, but this is unnecessary. The check is performed by comparing the readings of the pyrometer with those of a standard couple, their hot junctions being placed as near together as possible. Owing to the impossibility of making sure that the two junctions are at the same temperature, temperatures will be registered accurate to 20°.

Thermo-couples immersed in furnaces must be carefully protected. Conduction along the protecting tubes may be so great that the temperature of the couple may be far below that of the furnace. The general practice is to insert the couple in the furnace as far as possible and trust that this is satisfactory. A correction has also to be applied for the temperature of the cold junction. Rules are given for the application of this correction. The temperature must be kept constant, and various devices are used, such as burying the junction 8 or 10 feet below ground.

Methods of making thermo-couple junctions are described. Wire for the purpose is obtainable, being specially manufactured. The article concludes with an appeal to users of thermo-couples for industrial purposes to keep an accurate record of calibration data, operation, costs, etc., indicating at length the advantages to be gained thereby.

J. R. C.

I.—Glass-making Materials.

139. The Preparation and Testing of Pure Arsenious Oxide. ROBERT M. CHAPIN (*J. Ind. Eng. Chem.*, 1918, 10, 522).—The impurities commonly present in commercial white arsenic are SiO_2 , Sb_2O_3 , Fe_2O_3 , NiO , CoO , CaO , SO_3 , Cu , Pb , and Zn .

Five tests for purity are given, namely:—(1) Insoluble matter, left after treatment with ammonia. (2) Heavy metals, detected by passing H_2S through an ammoniacal solution. (3) Antimonious oxide, which renders the filtrate from (2) turbid when cooled in ice-water. (4) Sulphur and sulphides, detected by the addition of lead acetate solution to a solution of the sample in caustic soda. (5) Non-volatile matter.

Test (3) depends on the fact that antimonious sulphide is somewhat soluble in hot ammonia, but separates on cooling, excess of arsenious oxide precluding the presence of ammonium sulphide.

The author discusses the preparation of pure arsenious oxide in the laboratory, and he has been unable to discover a more practical means for attaining the desired end than crystallisation followed by sublimation.

During crystallisation, however, arsenious oxide strongly adsorbs many impurities, particularly antimonious oxide. Consequently, a "recrystallised" product may be more impure than the original material. The author recommends distilled water as the solvent for arsenious oxide, for it usually dissolves far less of any impurities present. The final crystals, however, are best deposited from a slightly acid solution. The absence of antimonious oxide is a rational and convenient index of the success of the operation. The solution is boiled for some time and then filtered. The filtrate is boiled down and the test for antimony is made. If present, it will be necessary to take off successive crops of crystals until a negative test finally results. The antimony-free mother liquor is treated with either 1 per cent. or $1\frac{1}{2}$ per cent. of its volume of concentrated hydrochloric acid and boiled down to evident saturation. It is rapidly cooled with frequent stirring and let stand overnight, when the crystals are filtered with suction and washed chloride-free. The yield varies, but will commonly be about 50 per cent. of the original. The product is subsequently carefully sublimed.

C. M. M.

II.—Glass: Manufacture and Properties.

140. **The Influence of Alumina on the Fusibility of Glasses.**—L. SPRINGER (*Ker. Rundschau*, 1917, 48, 243).—A reply to criticisms by F. Singer of a previous paper (*Ker. Rundschau*, 1915, 23, 273), and a repetition and extension of the work done and criticism of the conclusions drawn by Singer (*Ker. Rundschau*, 1917, 25, 142, etc.; this Journal, 1918, 2, 53 A.).

The experiments followed the lines of those of Singer very closely, but whereas Singer heated his glass batches in crucibles in a porcelain oven and withdrew them after heating to three definite temperatures, the author heated similar mixtures in small crucibles in a glass furnace and followed the progress of the fusion by withdrawing proofs on an iron at fairly frequent intervals. He claims that this is more instructive, as following more closely the actual glass-house practice.

The detailed progress of the melting and fining process is described for four distinct sets of experiments.

I. In which the effect of adding kaolin to glasses of the types $0.5\text{Na}_2\text{O}:0.5\text{CaO}:3\text{SiO}_2$ and $0.4\text{Na}_2\text{O}:0.6\text{CaO}:3\text{SiO}_2$ is studied.

II. In which the alumina is added in the form of hydrated alumina instead of kaolin.

III. Series of experiments to ascertain the effect of adding hydrated alumina to a soft soda-lime glass (composition not given).

IV. Experiments in which the alumina is introduced as pegmatite, alkaline silicates being simultaneously added.

Summarising the conclusions drawn by the author from the results of his experiments, it appears that:—

(1) In a high alkali glass, or a normal glass of the standard type $0.5\text{Na}_2\text{O}:0.5\text{CaO}:3\text{SiO}_2$, the addition of alumina, even in small quantities, decreases the fusibility of the glass and retards the fining.

(2) In glasses rich in lime, and correspondingly low in alkalis, the addition of alumina increases the fusibility and accelerates the fining, and this within limits in proportion to the amount of alumina added.

(3) It is immaterial whether the alumina be added in the form of kaolin or of hydrated alumina.

(4) The addition of pegmatite in varying quantities to the batch, replacing some or all of the sand and some of the alkali, and simultaneously introducing alumina, gave inconclusive results. In two cases the glasses were less fusible, in one no difference was observable, and in another the fusibility was increased. The glasses containing comparatively small quantities of pegmatite fined more rapidly in every case than the pegmatite-free glasses.

The author does not attempt to explain the contradiction between his results and those of Singer, but concludes that the effect of alumina on the fusibility of a glass depends on many circumstances,

and particularly on the composition of the glass, and cannot be stated as a fixed and definite rule.

In reply to Singer's remarks on the heat balance in the glass-melting process, the author points out that, according to Dralle (*Die Glasfabrikation*, 1, 220), the heat produced or absorbed in the glass-melting process falls under four main headings, namely:—

(1) Heat used in raising the temperature of the batch materials to the maximum temperature of the melting furnace (depending on the specific heats of the batch materials). (2) Heat used in the decomposition of the sulphates and carbonates in the batch. (3) Heat used in the melting of the silicates produced and solution of the excess silica (about 60 cal. for 1 kilo. of glass). (4) Heat produced by the chemical combination between the acid and basic oxides.

The heat used up in the first three sections is about twice as great in the case of a soda-ash batch and three times as great with a salt-cake batch as the heat liberated under section (4). The author claims, therefore, that his previous contention is correct, namely, that the introduction of part of the lime and alkalies already combined as silicates—as is the case when pegmatite is added to the batch—leads to the requirement of less heat in the furnace to bring about the melting of the glass.

The heat balances for four glass batches are calculated in support of this contention. J. H. D.

141. On the Relation between the Physical Properties and Chemical Composition of Glass. VIII. Molecular Compounds. E. WARD TILLOTSON (*J. Amer. Cer. Soc.*, 1918, 1, 76).—The author bases his method on the well-known physico-chemical theory that in a series of mixtures no compounds are likely to be present if the numerical value of the property measured gives a straight line curve when plotted against the composition. If, however, the curve is discontinuous, that is, consists of two or more lines which intersect one another, these intersections are assumed to indicate the presence of compounds, the compositions corresponding with these intersections giving the composition of the compound. The particular property chosen by which to investigate a series of glasses was the refractive index for ordinary white light, and the method was applied to the albite-anorthite and the CaSiO_3 - MgSiO_3 glasses for which data by other authors had been obtained, and also to the systems Na_2O - CaO - SiO_2 and Na_2O - BaO - SiO_2 , in which glasses were prepared expressly by the author for the investigation.

For albite-anorthite mixtures, both the refractive index and the density curves were straight lines, and the conclusion was drawn that no compounds were formed. Two breaks occurred in the curves for CaSiO_3 - MgSiO_3 mixtures, leading to the view that the compounds $\text{CaMg}_3(\text{SiO}_2)_4$ and $\text{Ca}_4\text{Mg}(\text{SiO}_2)_5$ were present.

The author's own experiments on glasses prepared from Na_2O , BaO , CaO , and SiO_2 led him to the conclusion that the following

compounds existed in the glasses at ordinary temperature:—
 $\text{Na}_2\text{O}, 2\text{SiO}_2$, $\text{BaO}, 2\text{SiO}_2$, $\text{Na}_2\text{O}, \text{BaO}, 3\text{SiO}_2$, $\text{Na}_2\text{O}, \text{BaO}, 4\text{SiO}_2$,
 $2\text{Na}_2\text{O}, 3\text{CaO}, 7\text{SiO}_2$.

The glasses corresponding with $\text{Na}_2\text{O}, \text{BaO}, 3\text{SiO}_2$ and
 $\text{Na}_2\text{O}, \text{BaO}, 4\text{SiO}_2$

were found to undergo devitrification readily. Owing to their high melting point, the series BaO-SiO_2 was not extensively investigated.

All the glasses were prepared on a small scale, and, when fused, poured on to an iron plate, and after annealing broken into fragments, from which pieces were selected for the refractive index determination. During the discussion, criticism centred mainly on the difficulty of obtaining accurate refractive index determinations with pieces of glass made by the author's method.

W. E. S. T.

142. The Production of an Easily Fusible Glass, without the use of Lead or Boracic Acid. E. ORTON, jr. (*Trans. Amer. Cer. Soc.*, 1903, 5, 305).—This investigation was undertaken with a view to producing a series of cones, supplementary to the original Seger series, which would replace the Cremer series. The principal points in which it was to differ from the Cremer series were:—(1) The omission of iron oxide as a flux; (2) the replacement of the boro-silicate frit by one less volatile and less easily attacked by acid kiln gases; (3) the cessation of the use of lime and other strong bases in the form of carbonates or oxides, which invited the formation of sulphates during the early portion of the burn.

The first attempt was made with common lime-soda glass as a frit, lime, as bone-ash, and alumina, as kaolin, being added until the formula was $0\cdot3\text{Na}_2\text{O}, 0\cdot7\text{CaO}, 0\cdot3\text{Al}_2\text{O}_3, 2\cdot1\text{SiO}_2$. This was not a success, so mixtures of glass and clay were prepared, but tests with these showed that no help was to be expected from the use of common glass as a flux at temperatures below those at which felspar becomes available. Six lime-soda glasses were next made in order to obtain a very fusible glass. The molecular composition of these was $0\cdot5\text{Na}_2\text{O}, 0\cdot5\text{CaO}$, with the silica varying from 0·5 to 2·5. By means of this series and a confirmatory one, it was found that a glass of the composition $\text{RO}, 2\text{SiO}_2$ is softest. Further decrease of silica content increased the refractoriness. A series in which a variable amount of alumina was added, the monosilicate ratio being maintained, showed that alumina did not increase the fusibility of the melts, but did markedly prevent devitrification. By varying the proportions of soda and lime, a glass of composition $0\cdot6\text{Na}_2\text{O}, 0\cdot4\text{CaO}, 2\cdot0\text{SiO}_2$ was adopted as the basis for further tests. When the soda was half replaced by potash, the melting point was lowered to 890° , but this not being low enough for the purpose, magnesia, barium, and zinc were in turn substituted for the lime. Zinc was found to give the most fusible glass, magnesia coming next, whilst lime gave the most refractory. Tests with

glasses in which these four bases were combined in every possible way were unsatisfactory, owing to the swelling of the glasses when fired as cones, but they showed the advisability of using a mixture. It was ascertained that the swelling was due to the absorption of sulphur from the kiln gases. Cones having Mg and Zn instead of Ca were found to be the most resistant, and it was decided to employ these bases in further tests.

J. R. C.

143. The Formation of Seed in Optical Glass Melts.

A. E. WILLIAMS (*J. Amer. Cer. Soc.*, 1918, 1, 134).—The formation of seed during the cooling of crown and boro-silicate glasses is described, the observations showing that:—(1) If the stirring were continued below a certain temperature bubbles appeared and increased in number as the stirring was continued. (2) If the stirring were stopped at a temperature above this minimum and the pot cooled without rapidly chilling the bottom, a layer of seed would occur on the bottom. (3) If one end of the pot were raised from the bottom of the furnace during cooling, seed would appear in that portion of the glass which was over the part of the pot still in contact with the furnace. (4) If the cooling were started at a temperature above that at which the seed apparently first appeared during the stirring, and the glass in the pot chilled rapidly, no seed appeared. (5) Small amounts of carbon dioxide were found in the bubbles so produced. (6) Pots of those glasses which were not stirred, but simply melted and fired until free from seed, showed no bubbles when cold.

Slow cooling between 1200° and 700° was found to increase the number and size of the bubbles.

The theories advanced to account for the formation of this seed were:—(1) The glass is supersaturated with dissolved gases at high temperatures, and these gases are evolved on cooling. (2) The seed is due to the evolution of gases from the bottom of the pot. (3) Gas in solution in the glass is evolved under the highly reduced pressure existent in the interior of the glass as the outside surfaces stiffen.

The third suggestion, it was thought, affords the best explanation of the phenomena, and the best remedy is rapid cooling of the glass to such a temperature that the viscosity of the glass is too great to allow of the formation of gas bubbles. The cooling should proceed uniformly from the top, sides, and bottom of the pot.

J. H. D.

144. The Etching of Opal and Crystal Glasses. (*Sprech-saal*, 1917, 50, 63).—Various solutions are given for producing a strong, even, matt effect. The addition of ammonium or potassium sulphate to the etching bath is recommended to prevent the appearance of uneven lines or spots.

Two receipts are appended as examples:—

(1) Potassium fluoride, 10 parts; hydrofluoric acid, 5 parts; ammonia (0.96 sp. gr.), 8 parts; potassium sulphate, 2 parts; water, 10 parts.

(2) Dilute 1 part of hydrofluoric acid with 5—10 parts of water, neutralise this solution with carbonate of soda, and then add a further $\frac{1}{2}$ to 1 part of hydrofluoric acid.

Dry etching powders are recommended, but the composition is not given.

Attention is directed to the importance of ensuring the cleanliness and freedom from grease of the articles to be etched, and also to the fact that the composition of the glass itself has an important bearing on the success of the process.

J. H. D.

145. Monosilicate Glasses. C. F. BINNS (*Trans. Amer. Cer. Soc.*, 1900, 2, 151).—The author quotes Seger, who says that a limit to the silica content in a glaze must be observed such that the acidity of the glaze must never exceed a trisilicate or fall below a bisilicate. In contradiction of this dictum, it was found experimentally that the monosilicate ratio was the best, and that glazes of this type can be produced which will mature well and bear a considerable range of fire. The alumina content of $0.2\text{Al}_2\text{O}_3$ was found best for general purposes, as in the glaze $0.7\text{PbO}, 0.3\text{CaO}, 0.2\text{Al}_2\text{O}_3, 1.6\text{SiO}_2$, though a higher content is advisable when the glaze has to stand a harder fire. It was mentioned in the discussion which followed the paper that the same glaze will act differently on a plastic and on a dust-pressed body.

J. R. C.

146. Fibres Resembling Fused Quartz in their Elastic Properties. K. E. GURNE (*Bulletin of the Bureau of Standards, Washington*, i., No. 1; from *Chem. News*, 1918, 117, 228).—An account of the preparation and properties of fibres made from fused steatite or soapstone ($\text{Mg}_3\text{H}_2\text{Si}_4\text{O}_{12}$) which resemble fused quartz in their elastic properties.

It was desired to obtain threads of 0.1 to 0.2 mm. in diameter and a metre long; such threads are somewhat difficult to prepare from fused quartz on account of the presence of air bubbles. The material in question was found to answer admirably; it had all the characteristic properties of fused quartz with the additional advantage that thick fibres do not break readily. In the oxygen-hydrogen flame the substance fused to a clear glass, and could be formed into threads of the requisite dimensions. The elastic fatigue of such fibres is very small—about one-third that of steel or phosphor bronze. The linear coefficient of expansion was found to be -0.0000045 .

C. M. M.

147. Measurement of the Expansibility of Hard Jena Glass. J. T. BOTTOMLEY and W. J. EVANS (*Phil. Mag.*, 1901, 1, 125).—During the course of work at high temperatures, the volume gauge of a constant volume air thermometer was made of Jena "Verbrennungsröhrenglas." Its expansibility had therefore to be determined, and to do this the weight thermometer method was used, measurements being made at 0° and 100° . The cubical ex-

pansion was found to be 0.00181. Similar experiments with Jena "Verbundglas" gave for its cubical expansion the value 0.0022.

J. R. C.

148. The Expansion of Porcelain and Glass at High Temperatures. C. HOLBORN and E. GRÜNEISEN (*Ann. Physik*, 1901, 6, 136).—The method employed was the same as previously described by the authors in the determination of the coefficient of expansion of platinum-iridium (Holborn and Day, *Ann. Physik*, 1900, 2, 506; 1901, 4, 104). Both porcelain and glass present greater difficulties than metals. The expansion is smaller, and the temperature of the rod is not easily made uniform owing to its low conductivity.

Berlin porcelain and the Jena boro-silicate glass 59^{III} were examined, the former up to 1000° and the latter to 500°. Two pieces of the glass were used, the first being a length from a thermometer capillary, whilst the second, from a different and more recent melt, was a solid rod. The expansions, λ , were found to be capable of representation by the expressions:

For the tube, $\lambda = (5184t + 0.804t^2)10^{-9}$.

For the rod, $\lambda = (5852t + 0.959t^2)10^{-9}$.

J. R. C.

149. On the Viscosity of Pitch-like Substances. F. T. TROUTON and E. S. ANDREWS (*Phil. Mag.*, 1904, 1, 347).—Soda glass was included in the investigations, determinations of its viscosity being made at 575°, 660°, and 710°. The coefficient of viscosity at these temperatures was found to be 1.1×10^{13} , 2.3×10^{11} , and 4.5×10^{10} respectively. The method used was to apply a constant torque to a tube of the glass (which was heated by being placed in a thick-walled iron tube, the temperature of which could be raised by a row of gas jets) and to observe the relative motion of the ends.

J. R. C.

150. The Electrostriction of Glass. A. WÜLLNER and M. WIEN (*Ann. Physik*, 1903, 9, 1217).—The increase of the internal volume of spherical and cylindrical condensers, produced by electrostriction, is, in general, smaller than it should be according to the value of Young's modulus, determined by compression or acoustically. This difference depends on the nature of the glass. Ten kinds were examined, and it was found to be greatest in flint glass and least in Thüringian glass. The after-effect, due to the discharge, observed by Quincke and Cantone, which slowly disappears, and which is the greater the longer the charge had continued, is attributable to the expansion of the glass due to the Joule effect. The value of Young's modulus found by compression is, in general, somewhat smaller than when it is acoustically determined. This difference is greatest with flint glass and least with Thüringian glass.

J. R. C.

III.—Lampworked and General Scientific Apparatus

151. **A Standard Apparatus for the Determination of Sulphur in Iron and Steel by the Evolution Method.** H. B. PULSIFER (*J. Ind. Eng. Chem.*, 1918, 10, 545).—In determining the amount of sulphur present in iron, several investigators have shown that hot concentrated hydrochloric acid gives more consistent results

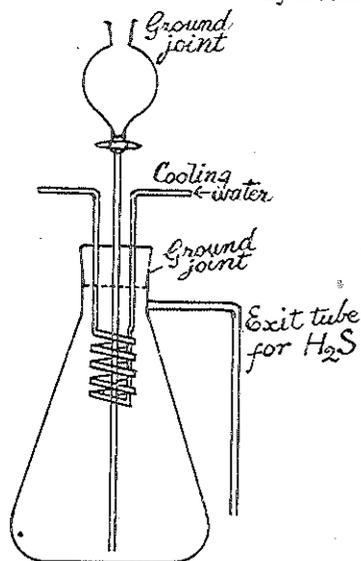


FIG. 13.

than dilute acid, but hot concentrated acid necessitates the use of all-glass apparatus. An American first made a piece of apparatus after the design shown in Fig. 13, but used a solid stopper and increased the number of ground-glass joints from three to eight. Other flasks made exactly to pattern and with only three ground joints were afterwards designed in Japan. The spiral reflux condenser is provided to maintain the acid at its maximum strength and to prevent the boiling over of the solution and the carrying over of ferrous chloride into the absorbing solution. As soon as a run is completed, the ground-in stopper must be loosened to prevent it from sticking in the neck of the flask.

S. E.

152. **A Safety Valve.** E. RITTENHOUSE (*J. Ind. Eng. Chem.*, 1918, 10, 633).—The safety valve shown in Fig. 14 is intended for use in a distilling flask when determining ammonia by absorption in standard acid solution. The valve is made entirely of glass with a drop of mercury in the bulb. It is very effective, never sticks, and is always set. The principle, namely, the pressure due to a column of mercury, can be adapted to all low-pressure work, both above and below that of the atmosphere.

S. E.

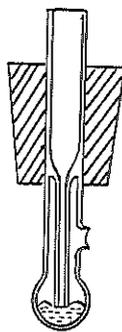


FIG. 14.

153. **A Modified Mercurial Viscometer for Determining the Viscosity of Volatile Liquids.** F. M. LIDSTONE (*J. Soc. Chem. Ind.*, 1918, 37, 148).—A viscometer previously described was found to be unsuitable for use with volatile liquids, as a cushion of vapour is formed at the junction of the mercury and the liquid

being tested. This cushion is formed whenever the vapour tension is greater than $P-H$, where P is the barometric pressure and H the head of mercury in the viscometer. To prevent this vaporisation, a pressure is applied equally to the top and bottom of the moving column in the viscometer. Then if p be the pressure applied, as read from a mercury manometer, there will be no vapour cushion formed unless the vapour tension of the liquids exceeds $P+p-H$. With the apparatus described, the viscosity of ether may be determined much above its ordinary boiling point.

S. E.

154. Pipette used in Titration of Oils for Acidity.

J. JACOBSEN (*J. Ind. Eng. Chem.*, 1918, 10, 633).

—Oil is sucked up into the lower limb of the pipette (Fig. 15) by a rubber bulb. The upper limb is filled with a suitable quantity of a mixture of ether and methylated spirit. Then the 3-way tap is turned, and the oil, followed by the ether-alcohol mixture, is run into the receiving flask ready for titration. In this way, the lower tube is cleared out automatically, and is at once ready for another sample.

S. E.

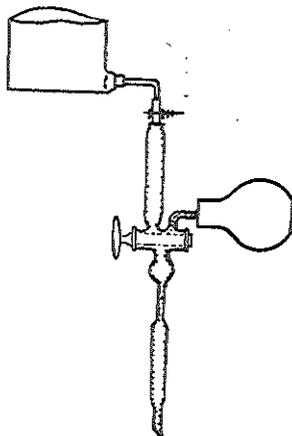


FIG. 15.

155. A New Form of Fractionating Column for Laboratory Use.

H. F. TAYLOR (*J. Soc. Ind. Chem.*, 1918, 37, 238).

—The column consists of a glass tube containing a number of lead discs supported horizontally at equal distances by suitably bent copper wires (Fig. 16). These discs have a central hole surrounded by several small perforations. Into these central holes fit the necks of inverted bulbs, which after insertion are flanged, so that they cannot pass backwards through the hole if the column be inverted.

When used with liquids of low boiling points, efficient working can only be secured if (1) the edges of the central hole are even and the bulb fits exactly, and (2) both loops on the copper wires fit tightly against the glass.

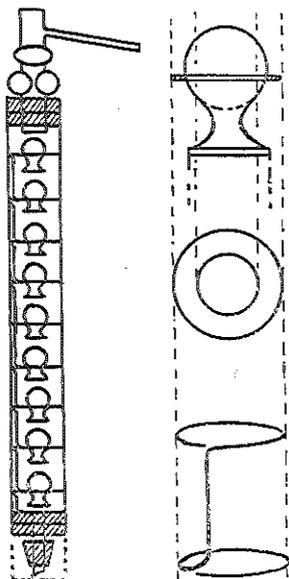


FIG. 16.

In such columns, liquid condenses and forms thin layers on the lead plates, so that the ascending vapours have to bubble through the returning liquid. As the liquid accumulates, the pressure of the vapour under the plate also increases until it is sufficient to raise the bulb from its seating and allow the returning liquid to run down to the next plate. These columns have been found to work efficiently on liquids with boiling points as low as 46° and as high as 200° .

S. E.

156. Determination of Carbonates in Limestone and other Materials.

J. F. BARKER (*J. Ind. Eng. Chem.*, 1917, 9, 786).—This method of determining carbonates depends on the principle of the hydrometer, the apparatus being sunk into a vessel of water. The sample of the carbonate is held in the bulb of the apparatus, and when the carbon dioxide is liberated the decrease in weight allows the apparatus to rise in the water, and the rise of the graduated tube records the percentage of gas released. In carrying out a determination, about 40 c.c. of hydrochloric acid (sp. gr. 1.15) are poured into the acid reservoir through the opening *A* (Fig. 17), 10 grams of pulverised limestone are inserted in the reaction chamber, and water is added drop by drop until the graduated tube is immersed to the zero point. The stopcock, *D*, is opened and the acid run on to the lime. As the action proceeds, the instrument slowly rises, and at the conclusion the point on the stem at the surface of the water gives the calcium carbonate equivalent to the carbon dioxide evolved from the sample. It is necessary to apply a small correction for changes in the temperature of the surrounding water during the course of the test.

S. E.

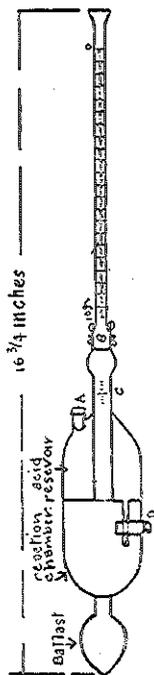


FIG. 17.

157. Grinding Glass Tips for Drop-Weight Apparatus.

E. C. H. DAVIES (*J. Amer. Chem. Soc.*, 1918, 40, 784). —In order to make glass tips for use in "drop-weight" surface tension measurements, the usual procedure is first to grind the

glass in a precision lathe until the cross-section of the tube near the tip is a circle, and, secondly, to grind down the end of the tube until it is flat and its edges are sharp. In this second operation, the glass is very liable to chip, and the abrasive used sometimes gets plugged up in the capillary. To avoid this and to give the tip a firm support during the grinding process, Wood's alloy can be drawn up into the capillary and allowed to solidify round the tip, so that in the grinding operation glass and metal are ground away together. To remove the Wood's metal from the tip and the capillary tube, it is only necessary to put the end of the tube into boiling water and allow the alloy to melt.

S. E.

158. An Improved Form of Thermo-regulator. J. B. FERGUSON (*J. Amer. Chem. Soc.*, 1918, 40, 929).—The essential feature of this regulator is that the adjustments are made by a plunger working in a plunger tube, and thus varying the height of the mercury with respect to a fixed platinum wire.

The apparatus (Fig. 18) is made entirely of glass, with the exception of the two brass tubes and screws on the plunger and plunger tube and the brass clips holding the wires. S. E.

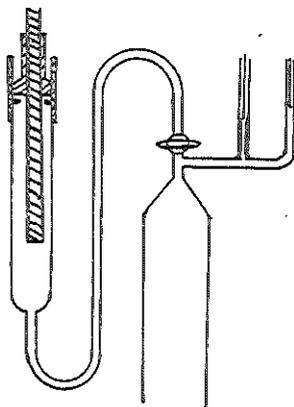


FIG. 18.

159. Tungsten Filaments. (*J. Ind. Eng. Chem.*, 1918, 10, 547).—

A new German process for making tungsten filaments is based on the idea of forming the filament of one long crystal, and it is claimed that such unicast filaments are softer at the ordinary temperature and harder at high temperatures than are the drawn-wire filaments. Tungsten is made to crystallise gradually by mixing the tungsten powder with thorium oxide. The mixture is squirted through diamond dies, and the filament drawn through a chamber in which it is rapidly heated to between 2400° and 2600°. The speed of the filament passing through this chamber is about 2½ miles per hour, which is rather slower than the crystallisation velocity of tungsten. The filament in this state is ready for use in a lamp without further treatment.

S. E.

IV.—Decorated Glass.

160. Art of Colouring Glass. H. ROSENTHAL (*J. Ind. Eng. Chem.*, 1917, 9, 734).—It is well known that white glass which has been exposed to the action of sunlight for some time undergoes a change of colour. The paper describes experimental work carried out with the object of producing coloured glass from white by subjecting the latter to the action of certain artificially produced short wave-lengths of light, using the ordinary quartz mercury arc, an X-ray tube, the Coolidge X-ray tube, and then a special X-ray tube for producing negative electrons.

This method, which is fully described, opens up a new art in the colouring of glass and analogous substances, such as porcelain,

quartz, and some of the precious and semi-precious stones, particularly those coloured by manganese. In the treatment of white glass for optical and scientific purposes, peculiar photometric and spectroscopic, spectrophotometric results can be obtained. The "cross-fire theory" has also been made use of. A side of a cube of glass with a 2-inch square face was "rayed" by a beam $\frac{1}{2}$ -inch in diameter. The glass side nearest the tube was coloured darkest and shaded off towards the centre, and as each of the eight sides were rayed, a small cubical spot was found in the centre of the cube equal in colour to any one of the outside surfaces. After repeated tests for index of refraction, strength, etc., no physical changes could be detected in the treated glasses, except that of colour, which extends into and throughout the material, depending on the voltage and the thickness of the glass.

White optical glass after being coloured by this process has the same qualities and characteristics and is capable of performing the same functions as the original clear glass tinted or coloured by the slow action of the sunlight extending over many years. There is, therefore, the problem of transparency besides the purely spectral problem, and from the chart given it is shown that the spectrophotometric curves of glass coloured by this method have a high degree of transparency and very little distortion in the visible spectrum.

The colouring of glass follows the law that "the work done by any force varies with the time during which it acts." X-ray light follows the law that the work done by a given light varies inversely as the square of the distance from the source of light and also varies with the quantity of current passing through the tube, other conditions remaining constant. Another factor determining work done is the penetration of the tube.

The author suggests that a direct physical change in the material, or a direct molecular rearrangement, has taken place. Considering that by the application of heat, molecules can be rearranged, the action would appear, in the author's view, as physical in character rather than chemical. C. M. M.

V.—Optics and Optical Instruments.

161. **A Differential Refractometer.** G. A. SHOOK (*J. Ind. Eng. Chem.*, 1918, 10, 553).—This instrument is the result of an attempt to develop a simple but accurate refractometer for measuring the difference of the refractive indices of two liquids. It is of the Abbe type, but the face of each of the refracting prisms is divided into two parts by means of a groove, so that a drop of a standard liquid may be placed on one half of the face and a drop of the liquid under investigation on the other. The prisms can

be rotated and the amount of rotation measured by a micrometer screw, the smallest division of the micrometer corresponding with a difference of about 0.00005 in the indices. In order to get a sharp dividing line, monochromatic light, obtained by passing the light from an electric lamp through a red glass, is necessary. After passing through the refracting prisms, the light passes on to a telescope provided with cross-wires, and with a screen for shutting out the light from either one or other half of the prisms. The micrometer screen is turned until the dividing line of each half of the prisms is in turn brought up to the cross-wires, and the difference between the two micrometer readings indicates the difference in the refractive indices of the two liquids between the prisms. S. E.

162. Note on the Use of the Dipping Refractometer. W. W. RANDALL (*J. Ind. Eng. Chem.*, 1918, 10, 629).—In investigating the cause of some irregular results obtained for the refractive indices of certain alcoholic solutions, it was thought that an uncertainty in the temperature of the liquid contained in the metal cell fitted to the instrument would be sufficient to cause the results to be untrustworthy. When glass beakers were used instead of the metal cup, normal readings were obtained. Comparative measurements of the temperature of the solution in beakers and in metal cups were made, and it was found that the liquid in the metal cups was practically 0.5° hotter than that in the beakers. It was also noticed that this variation in temperature was closely connected with the difference between the temperature of the bath and that of the atmosphere. Hence it was concluded that heat is conducted from the air to the contents of the metal cup through the metal parts of the instrument. S. E.

163. Relative Dispersion and Achromatism. F. E. LAMPLOUGH and I. M. MATHEWS (*Trans. Optical Soc.*, 1918, 9, 83).—The irrationality of dispersion makes it impossible to achromatise a crown and flint lens for more than two colours, a secondary spectrum being produced. If glasses of the same ν exhibit a similar run of dispersion, there can be no possibility of reducing a secondary spectrum except by sacrificing, to a proportionate extent, the difference in the dispersive powers of the two glasses. This involves deeper curves, and consequently increase of spherical aberration, colour differences of spherical aberration, and thicker glass. If, on the other hand, glasses of the same mean dispersion have a similar dispersion, a dense barium crown and a light flint of equal dispersion and different ν could be chosen to give complete achromatism. In order to examine the possibility of attaining this, the refractive indices of thirty glasses, for thirteen wavelengths, were used to obtain the relative dispersions for these lines and their departure from the mean. It was found that the relative dispersions are not accurate functions of the dispersive power, or of the mean dispersion. A method of selecting glasses for constructing triple objectives was described. J. R. C.

164. Graphical Methods of Correcting Telescope Objectives. A. O. ALLEN (*Phil. Mag.*, 1918, 35, 471).—The objectives considered are doublets, although the method, it is stated, can be extended; an air-gap is assumed to exist between the lenses. The problem is to express the spherical aberration, and the offence against the sine condition as functions of the refractive indices, the curvatures, and the position of the object, and to represent the expressions graphically. The expressions are theoretically derived and their application is illustrated by numerous examples.

J. R. C.

165. Skew Refraction through a Lens. J. D. EVERETT (*Proc. Roy. Soc.*, 1903, 71, 509).—The paper explains the curves obtained by receiving on a screen at certain distances the hollow pencil which emerges from an annulus of a lens placed at an angle of about 40 degrees to the incident beam. The treatment is mathematical. Twelve points, 30 degrees apart, are taken on the annulus as points of incidence, and the direction cosines of the corresponding emergent rays are calculated. The equations of the twelve rays thus found enable twelve points of the section, made by a plane at any distance from the lens, to be plotted. Through these a curve can be drawn.

J. R. C.

166. On Refraction at a Cylindrical Surface. A. WHITWELL (*Phil. Mag.*, 1903, 6, 46).—The paper describes and illustrates the position and form of the focal areas produced by the refraction at a cylindrical surface of divergent and convergent light. The subject is treated analytically, and the results obtained are represented diagrammatically.

J. R. C.

167. On Astigmatic Aberration. R. J. SAWTER (*Phil. Mag.*, 1903, 6, 524).—The paper gives a simple explanation of the shadow phenomena observed by S. P. Thompson in his researches on aberration of lenses, in the case where the aberration is astigmatic. It is found that the presence of astigmatic aberration in a non-homocentric beam is accountable merely for the rotation shown in the image formed by an object placed in the beam.

J. R. C.

168. Single Piece Lenses. T. H. BLAKESLEY (*Phil. Mag.*, 1903, 6, 521).—It is assumed that the lens is completely determined in shape and size when the radii of curvature of the bounding surfaces and the distance between these surfaces are given. Dimensions which are measured at right angles to the axis do not affect the focussing properties of the lens except in the second order of small quantities, and they are not considered. If the thickness is unity, there are only two variables, and the properties of the lenses can be represented under a simple system of co-ordinates. A diagram based on this principle is given, and its use illustrated by examples.

J. R. C.

169. Optical Testing by Hartmann's Zonal Method. H. LEHMANN (*Zeitsch. Instrumentenkunde*, 1903, **23**, 289).—The method is applied to the determination of the colour curve of an objective. Examples are also quoted showing its application to the construction of parabolic mirrors. J. R. C.

170. Determination of the Chromatic Curve of Objectives. G. EBERHARD (*Zeitsch. Instrumentenkunde*, 1903, **23**, 82).—In the method described, the objective is used as the camera lens of a spectrograph. Photographs are taken of the spectrum of an iron arc, and the position of the focus for various wave-lengths is thus ascertained. J. R. C.

171. Zonal Aberration and Astigmatism. K. STREHL (*Zeitsch. Instrumentenkunde*, 1903, **23**, 6).—A continuation of previous papers on zonal aberration. Defects of this nature in telescope objectives are a frequent source of bad definition. The astigmatism which it produces is mathematically considered. J. R. C.

172. Light Intensity in the Prismatic Telescopes. H. KRÜSS (*Zeitsch. Instrumentenkunde*, 1903, **23**, 8).—The intensity of the light transmitted by several telescopes was determined photometrically, and the loss found to be of the same order as calculated in a previous paper (this vol., A., No. 113). Makers usually record as the brightness of the image the ratio of the aperture of the objective to the square of the magnification, neglecting the loss by absorption. The latter depends on the construction of the instrument, the kinds of glass employed, and the degree of polish of their surfaces, and may, in the author's opinion, be very considerable. J. R. C.

173. Disadvantages of Cemented Objectives. G. EBERHARD (*Zeitsch. Instrumentenkunde*, 1903, **23**, 274).—The author used Hartmann's methods of testing objectives in order to examine cemented and uncemented objectives. He concludes that the latter type is preferable. J. R. C.

174. Investigations on Objectives. J. HARTMANN (*Zeitsch. Instrumentenkunde*, 1904, **24**, 1, 33, 97).—The author describes in these papers, in full detail, his tests of lenses and lens systems for spherical, chromatic, and zonal aberrations and astigmatisms. In the last paper a description is given of an optical bench specially designed for use in these tests. J. R. C.

175. Types of Glass of Increased Transparency to Ultra-violet Light. E. ZSCHIMMER (*Zeitsch. Instrumentenkunde*, 1903, **23**, 360).—On account of the absorption shown by ordinary crown and flint glass, quartz and fluorspar have been used chiefly for prisms and lenses when it has been desirable that ultra-violet light should be transmitted through an optical system. The author

states that he has discovered a method by means of which glass can be produced which will transmit 50 per cent. of the rays of wave-length $288 \mu\mu$ when 1 mm. thick. He gives the D-line refractive index and the relative dispersion of four such glasses. These are Schott's U.V. Crown 3199, U.V. Flints 3248 and 3492, and a heavy U.V. Flint S249. He also refers to a glass, 786^{III}, which transmits only the blue, violet, and ultra-violet when 1 mm. thick. This is useful for bacteriological investigations. He states that the U.V. crown glass is very suitable for light-healing purposes.

The compositions of the glasses are not given. J. R. C.

176. The Transparency of a Number of Jena Optical Glasses for Ultra-violet Rays. H. A. KRÜSS (*Zeitsch. Instrumentenkunde*, 1903, 23, 197, 229).—The absorption of ten glasses made by Schott has been determined between the wave-lengths $480 \mu\mu$ and $309 \mu\mu$. The literature of previous work is given, and short notes on the methods of some of the observers are added. The only previous quantitative measurements in the ultra-violet were carried out by Vogel, who used a Glan photometer for wave-lengths $677 \mu\mu$ to $436 \mu\mu$, and a photographic method for shorter wave-lengths. The influence of reflection at the surfaces of the test-piece was calculated by him from Fresnel's formula.

The author, in the investigation now recorded, used a fluorescent screen to enable him to compare the intensities of the ultra-violet. Some essential conditions which a good spectrophotometer must satisfy are set out. The whole optical system must consist of media transparent to ultra-violet light. The photometer itself must fulfil the Lummer-Brodhun photometer fundamentals, namely, no light must enter the photometer except from the light source, and the border of the two fields must be sharp, disappearing when they are of equal intensity. Further, the ratio of the intensity of the two fields must be independent of the unavoidable variations of the light source. This condition can only be satisfied if the two images originate from the same source.

The apparatus used was arranged as follows. Monochromatic light was obtained spectroscopically and focussed on a slit. After passing through a polarising Nicol, it is made parallel and impinges on a diaphragm containing two circular openings, 5.5 mm. diameter, situated symmetrically with regard to the axis of the optical system. The two resulting pencils are polarised by two Nicols the vibration directions of which are mutually perpendicular. They then pass through the test-piece and a piece of glass inserted to compensate for loss by reflection respectively. The pencils pass through a biprism which makes them intersect, and another biprism is placed with its edge at the point of intersection. This divides each beam into two, one part being refracted parallel to the axis and the other away from the axis. The two outer beams are cut off by a diaphragm, and therefore two semicircular fields are obtained with their diameters in contact. After passing through an analysing Nicol, which is capable of rotation, measurable by a

divided circle, the axial pencils fall on a fluorescent screen, and the resulting images are examined with an eye-piece.

For a fluorescent screen, a solution of the potassium salt of fluorescein in glycerine was first used. It gives a very intense green fluorescence, and was spread in a layer 0.5 mm. thick on a quartz plate. It failed to give a sharp dividing line between the two images, as the fluorescence produced on the front side of the layer causes a diffuse fluorescence throughout the remainder. Schön's screen, consisting of a piece of thin tracing paper saturated with a strong solution of double sulphate of quinine and dried, was found to answer the purpose better.

The induction spark was used as the source of light, Cd, Mg, Zn, Al, and Fe electrodes being employed. The absorption was measured in intervals of $20\ \mu\mu$, except for wave-lengths $448\ \mu\mu$ to $396\ \mu\mu$, when intervals of $10\ \mu\mu$ were used. The theory of the method is developed, and it is shown that if A is the fraction to which the incident light is reduced by unit thickness, a and b denoting the two absorbing glasses, and if α is the angle through which the analyser must be rotated to pass from one equalisation to the next, then $A^{a-b} = \cot^2(45^\circ + \alpha/2)$.

If Bunsen's coefficient k be used, then $A = e^{-k}$.

There are three sources of error: (1) The reading of the vernier on the divided circle, (2) the difficulty in ascertaining exactly the position of equalisation, and (3) diffuse light. The first two may be decreased with practice. Jena ultra-violet filters were used to cut off the diffuse light, but a further complication is introduced by the fact that many types of glass commence to become fluorescent at $430\ \mu\mu$. The error due to these causes was calculated and found not to exceed 0.5 per cent.

The glasses examined were boro-silicate crown, telescope crown, lime silicate crown, very heavy baryta crown, baryta light flint, baryta heavy flint, and ordinary and heavy silica flints. Some of them were coloured. Unfortunately, the compositions are not given. The pieces were 15 sq. mm. in cross-section, and the lengths varied from 1 to 100 mm. They were all free from bubble except telescope crown.

The results are given in tabular form and illustrated graphically.

J. R. C.

177. The Employment of a Thermopile in the Ultra-violet. H. PFLÜGER (*Phys. Zeitsch.*, 1903, 4, 614, 861).—In the experiments in question, condensed induction sparks were used as the sources of light. These are preferable to the arc on account of their energy in the ultra-violet. The optical system of the spectrometer was of quartz, and the absorptions of calcite and quartz plates were studied as far as the apparatus would allow. With the thermopile, a deflection of 224 scale divisions at a wave-length of $214\ \mu\mu$ was obtained.

In a further investigation, the optical system was of fluor spar, and by means of the aluminium spark a deflection of 200 scale

divisions was observed at wave-length $186 \mu\mu$. The author states that the apparatus was designed for the study of glass absorptions.

J. R. C.

178. The Absorbing Power of Some Glasses. H. PFLÜGER (*Phys. Zeitsch.*, 1903, 4, 429).—The measurements were made with the aid of a thermopile. For wave-lengths down to $400 \mu\mu$ a Nernst lamp was used as the source of light, and for shorter wave-lengths an arc lamp. The lenses of the spectrometer were of glass, the prisms of quartz. The percentage absorptions of plates of eight different glasses about 1 cm. thick were determined at six wave-lengths ranging from $640 \mu\mu$ to $357 \mu\mu$. The compositions of the glasses are not given, but only their numbers in the list of Schott and Gen.

J. R. C.

179. A New Interference Photometer and the Reflecting Power of Selenium, Cyanine, and Glass. P. G. NUTTING (*Phys. Rev.*, 1903, 16, 129; *Phys. Zeitsch.*, 1903, 4, 201).—By means of an arrangement of Nicol prisms, a calcspar crystal, and a wedge compensator, two beams of light polarised at right angles to each other were made to interfere. The principle is the same as that of Koenigsberger's photometer (this vol., A., No. 104).

Jena telescope crown, baryta flint, and a new glass, S228, were tested, but the compositions are not given. From each glass plates were cut 1.5 and 5 mm. thick; also a wedge, of such angle that only reflection at the first surface was observed. It was found that there is scarcely any rise in the reflecting power in the region of the ultra-violet absorption band, and there were no signs of anomalous dispersion.

J. R. C.

180. A Polarisation Photometer and its Use for Measurements in the Ultra-Violet and for the Determination of Reflection. J. KOENIGSBERGER (*Phys. Zeitsch.*, 1903, 4, 345).—The author indicates how his photometer can be used to ascertain the reflecting power of a substance (compare preceding abstract).

J. R. C.

181. On the Stresses in Solid Bodies due to Unequal Heating, and on the Double Refraction Resulting Therefrom. Lord RAYLEIGH (*Phil. Mag.*, 1901, 1, 169).—When a piece of glass, previously in a state of ease, is unequally heated, double refraction usually ensues. This is produced by the stresses caused by the unequal expansions of the various parts. The author develops the theory of the production and effect of these stresses, and considers the influence of time on the double refraction of a heated plate of glass. A short note shows how some of the theoretical points may be illustrated experimentally.

The appearance, when viewed between crossed Nicols of "toughened" glass prepared by sudden cooling in oil, is described. A great want of uniformity was observed, which was greatly decreased when the outer layers were dissolved away by hydro-

fluoric acid. The cause of the "toughening" may be a special crystalline condition, due to the sudden cooling, or it may be that the outer layers being in a state of compression, a degree of bending is harmless which in the normal glass would be fatal.

J. R. C.

182. The Change in the Optical Behaviour of different Glasses through Elastic Deformation. F. PÖCKELS (*Ann. Physik*, 1903, 9, 220).—An addition to a previous paper on the subject (this vol., A., No. 96). In the paper referred to, the value of Young's modulus for the glass O 428 had not been determined, and was calculated from its chemical composition by means of Winkelmann's formula. The value was assumed to be 4,720 kg./mm.², and ν was found to be 0.268. An experimental determination gives the value 7,940 kg./mm.², ν being 0.187. The anomalies which formerly appeared in the case of this glass now vanish. In particular, the velocity of the extraordinary ray, as with the other glasses, is smaller when the glass is subjected to non-hydrostatic pressure. It is also found that, of all the glasses examined, this one exhibits the smallest absolute change in refractive index and the strongest double refraction for a given expansion. Observations by the author, in conjunction with Pulfrich, show that the influence of thermal expansion on the velocity of light is different from that of an equal, mechanically produced expansion. On this account, it appears useful to express the optical change as a function of the principal pressure instead of the expansion. The author shows how this can be done, and gives a table of the constants involved for the seven glasses examined.

J. R. C.

VI. Fuels, Refractories, and Furnaces.

183. Special Pots for the Melting of Optical Glass A. V. BLEININGER (*J. Amer. Cer. Soc.*, 1918, 1, 15).—The special properties desired in pots for the melting of optical glass are (a) high refractoriness and capability of withstanding the hydrostatic pressure of the molten glass, (b) resistance to corrosion by the batch materials and molten metal, and (c) freedom from iron oxide or other colouring agents.

As such conditions have been difficult to attain in the ordinary type of fireclay pots, experiments were made with pots more nearly approaching the type of hard porcelain. Very successful results were attained with the following clay mixture:—

Calcine, 43 per cent.

Kaolin, 25 per cent.

Plastic bond clays, 25 per cent.

Felspar, 7 per cent.

The "calcine" was composed of a mixture of 80 per cent. kaolin, 10 per cent. flint, and 10 per cent. felspar, fired at S.K. 14 (1410°), and afterwards ground. An excessive proportion of dust (through 80 mesh) in the ground calcined material should be avoided, as this gives the pots a tendency to crack on cooling. Trouble and expense may be avoided by using biscuit pottery pitchers where the composition is suitable, for example, those with a granite body.

The pots may either be pressed by hand in the usual manner or cast. Very successful results have been attained by casting a mixture of the following percentage composition:—Ground white biscuit ware, 48; plastic bond clay, 23; kaolin, 24; felspar, 5.

The casting slip contained 80 per cent. of solids and 20 per cent. water, the electrolyte used being a mixture of equal parts of sodium silicate and sodium carbonate, and the amount of electrolyte added being 0.20 per cent. of the dry weight of the body. A brief description of the casting process is given. The thickness of the cast pot walls varies from 2 to 3 inches, and they can be dried without difficulty in three weeks. The porcelain type of pots should be heated to at least 1400° before any batch is introduced, otherwise the advantages of this type are lost. J. H. D.

184. The Binding Strength of a Number of Clays between Normal Temperatures and Red Heat. C. W. SAXE and O. S. BUCKNER (*J. Amer. Cer. Soc.*, 1918, 1, 113).—In this paper an attempt is made (1) to find out to what extent breaking tests carried out on clays dried under standard conditions give trustworthy information as to the properties of these clays dried under ordinary factory conditions, and (2) to follow the variation in the bonding strength of the clays as they are heated up to red heat.

It was shown that there is a considerable variation in the strength of clays dried thoroughly at 110° and similar dried clays after being exposed to an ordinary factory atmosphere for some time. Clays differ widely in respect to this divergence owing to their varying capacity for absorbing moisture.

The strength of the test pieces showed little change as they were heated up to 325°, the strength of the hot pieces being generally less than that of the clay dried at 110° and cooled before being broken.

During the dehydration period and at temperatures above this, the bonding strength of the clays increased quite rapidly.

A sketch of the apparatus used to determine the breaking strength of the test pieces at definite temperatures whilst still in the furnace was given. J. H. D.

185. The Effect of Electrolytes on some Properties of Clays. H. G. SCHUBERT (*J. Amer. Cer. Soc.*, 1918, 1, 201).—The author has studied the effect of the addition of gradually increasing quantities of various electrolytes on the properties of ball clay and mixtures containing ball clay or china clay with flint and

grog. The conclusions drawn were that sodium hydrate, sodium silicate, and sodium carbonate in the order named:—

- (a) Increase the strength of the clay in the dry piece.
- (b) Lower the amount of water necessary to develop plasticity.
- (c) Decrease the volume shrinkage. (Caustic soda increased the volume shrinkage of the pure ball clay and the china clay mixture.)
- (d) Increase the density.
- (e) Decrease the porosity.
- (f) Decrease the burning shrinkage.

In most cases, the addition of calcium hydroxide or mineral acids has the contrary effect.

The effect produced increases in most cases with increasing quantities of electrolyte until a maximum is reached, when the addition of further quantities of the electrolyte diminishes the effect.

J. H. D.

186. Zirconia as a Refractory. E. H. RODD (*J. Soc. Chem. Ind.*, 1918, 37, 213R).—Zirconia has long been known as an oxide of great chemical stability and resistance to heat, but only quite recently has its employment as a refractory material come within the range of commercial possibility. Large deposits of the oxide have lately been discovered in Brazil. The mineral occurs in two forms, containing 90—93 per cent. of ZrO_2 and 73—85 per cent. of Zr_2O_3 . No trustworthy estimate of the quantity of material contained in these deposits, which are at present difficult of access, is yet available, but there appears to be no fear of their being soon exhausted, however surprisingly the demand may grow. Zirconia is one of the most refractory oxides known, its fusing point being in the neighbourhood of 3000° . Even when containing about 1.25 per cent. of silica and ferric oxide it does not melt below 2560° . The thermal conductivity of the pure fused material is very low, and it has a very low coefficient of expansion (8.4×10^{-7}), which compares very favourably with that of carborundum (6.58×10^{-6}) or alundum (7.1×10^{-6}). Such a substance can clearly withstand sudden changes of temperature without fear of fracturing. Chemically, zirconia is extremely inert, being highly resistant to acids, fused alkalis, fused quartz, or molten glass. No other material known to the chemist possesses such a combination of desirable refractory properties. These very properties have so far hindered its immediate development on account of the difficulties encountered in working such a material. These difficulties, however, are being slowly surmounted. One undesirable property of zirconia is its tendency at high temperatures, in the presence of nitrogen or carbon, to become converted into nitride or carbide.

Early attempts in Germany to obtain satisfactory zirconia ware were not so successful as was anticipated, the finished articles frequently developing cracks. This fault was due to the extremely high firing temperature required to get a fully shrunk body and to the difficulty experienced in finding a suitable binding material.

Whether zirconia can be introduced as a refractory on a large scale depends on considerations of expense. The refractory properties of the crude material as it comes on the market are very high, although, of course, inferior to those of pure zirconia. It is supplied as a heavy, reddish-brown powder, density 4.4—5.3, most of which will pass through a 90-mesh sieve. According to analysis, it contains about 68.9 per cent. of ZrO_2 , 14.98 per cent. of $ZrSiO_4$, 12.22 per cent. of SiO_2 , 3.6 per cent. of Fe_2O_3 , 0.6 per cent. of TiO_2 . This crude material could undoubtedly find many useful applications, especially where the presence of so much iron is of no consequence. The choice of a suitable binding material is of first importance, since it is necessary to bring about gritting at only a moderately high temperature, without unduly reducing the refractoriness. The zirconia can also be made up into bricks of great hardness and strength, so that for some purposes it may perhaps take the place of silica bricks, which are very brittle and frequently give trouble. Zirconia bricks, however, need a high firing temperature.

For some industrial purposes, a purer zirconia, in particular one free from iron, is likely to be required. For example, in the manufacture of glass, and especially of optical glass, it is essential that the material of which the pots are composed shall not contain iron, which may be dissolved out by the melt. The separation of iron from zirconia is a task of no small difficulty, and it is fairly certain that iron-free zirconia will be available only for special purposes on a large scale.

C. M. M.

187. Notes on the Remediable Causes of Unreliability Encountered in Thermoelectric Pyrometry, especially in Systems of the Base-metal Type. G. E. M. STONE (*Trans. Faraday Soc.*, 1918, 13, 348).—Non-homogeneity of the materials from which base-metal couples are made is a serious obstacle to accurate working. Such a state, not necessarily present in new material and in the cold state, may very soon be set up, due to temperature and heat treatment, while in use. Iron, nickel, and other materials capable of undergoing molecular transformation are liable, when used as one of the elements of a thermocouple, to cause varying *E.M.F.*'s for the same temperature, owing to change of molecular state throughout the element. Therefore metals which undergo molecular change on heating should not be used in thermocouples. A method of testing for non-homogeneity is described.

The author criticises the design of present-day thermoelectric pyrometers and pyrometer installations, and deals with the welding of the two rods of the thermocouple to form the hot junction, the insulation of the rods, the non-interchangeability of voltmeters and recorders, and the low terminal resistance of voltmeters in base-metal thermocouple installations. Greater care in welding the rods to form the hot junction would lead to fewer breakages there. Low terminal resistance of indicators and recorders makes the

measurements very susceptible to errors caused by changes of resistance in the circuit formed by the thermocouple, connecting leads, and measuring instruments, changes due to temperature variations or to a little dust between the contacts. The indicators examined by the author had resistances from 2.7 to 5.3 ohms. He advocates the use of one with a resistance of 400 ohms.

Recorders should be fixed on a mount which will not warp and which does not allow magnetic leakage. Circular recorder sheets should always be inspected to see if the centring is correct. Also the pen and the ink flow must work properly to give a correct record, for an intermittent flow of ink to the pen has been found to cause the recorded temperature to deviate widely from the true temperature.

In the written discussion on the paper, it was stated that the latest Hoskins' (nickel-chromium) alloys do not give parasite *E.M.F.*'s due to non-homogeneity. Indicators and recorders are not generally interchangeable, because the outfits are usually made for some specific requirement.

A high-resistance millivoltmeter indicator is much more delicate than a low-resistance one which has substantial pivots and control springs. Hence the more robust low-resistance indicator is usually installed in base-metal thermocouple systems. J. D. C.

188. Bibliography on Pyrometers. Sir R. HADFIELD (*Trans. Faraday Soc.*, 1918, 13, 362).—A very useful and interesting list of pamphlets, papers, cuttings, patents, and books on pyrometers, arranged in chronological order. J. D. C.

189. Production of High Temperature and its Measurement. E. F. NORTHRUP (*Trans. Faraday Soc.*, 1918, 13, 212).—The author discusses the melting efficiency of furnaces, and gives an account of his conception of the ideal melting furnace. With the object of attaining this ideal, he has devised, and had constructed, an experimental Northrup-Ajax furnace can be used for melting either at atmospheric or reduced pressure. A temperature of 1600° can be rapidly attained, and the melting efficiency is 60 per cent. of the energy supplied. The author thinks that with a larger furnace it will be possible to reach 2000° and obtain a higher efficiency. He thinks that these furnaces should be particularly adapted to the melting of optical glass, high-melting alloys, brass, gold, silver, etc.

This, as yet, experimental Northrup-Ajax furnace can be used for melting either at atmospheric or reduced pressure. A temperature of 1600° can be rapidly attained, and the melting efficiency is 60 per cent. of the energy supplied. The author thinks that with a larger furnace it will be possible to reach 2000° and obtain a higher efficiency. He thinks that these furnaces should be particularly adapted to the melting of optical glass, high-melting alloys, brass, gold, silver, etc.

The section of the paper dealing with high temperature measurement is confined to direct insertion pyrometers. Up to about 1300°, a properly constructed and protected platinum-rhodium thermocouple can be used. A thermocouple of tungsten-molybdenum can be used for extreme temperatures if it can be protected from access of hot gases.

The instrument measuring the *E.M.F.* of thermocouples must be very sensitive, and for works practice must be robust. A description is given of the Northrup pyrovolter, which is designed to fulfil these conditions. To overcome the thermal effect of the current passing through the voltmeter, the *E.M.F.* of the thermocouple is first balanced, on the potentiometer principle, by means of a dry battery, which is part of the instrument, and then the deflection given by the balancing *E.M.F.* is read. In this way the error caused by the resistance of the leads is obviated.

For the measurement of temperatures above 1300°, the author suggests the use of molten tin. While this has not yet been tried in the works, it has been successfully used in the laboratory. The instrument is constructed on the general lines of a large mercury thermometer, a description of a suitable construction being given in the paper.

Tin does not form a carbide in the presence of graphite, and maintains its purity in the presence of carbon monoxide at the highest temperature. The resistivity and volume of molten tin increase in a strictly linear manner with increase of temperature. Temperatures can be measured by determining the resistivity of a tin pyrometer (see Northrup and Sherwood, *J. Franklin Institute*, October, 1916), and recently the author has developed a tin pyrometer which depends for its indications upon the linear expansion of tin. A brief account of this instrument is given.

Unlike a thermocouple, the tin pyrometer does not indicate a point temperature, but registers the mean temperature over the space occupied by the bulb. It is intended only for permanent installations in an industrial furnace of comparatively large dimensions, and as now constructed must be maintained approximately in a vertical position.

J. D. C.

190. The Automatic Control and Measurement of High Temperatures. R. P. BROWN (*Trans. Faraday Soc.*, 1918, 13, 246).—The author states that a nitrogen gas thermometer is the most satisfactory for measuring temperatures up to 425°; a thermocouple with one wire of nickel 90 per cent., chromium 10 per cent., and the other wire of nickel 98 per cent., aluminium 2 per cent., is preferred for temperatures to 1100°; a platinum-rhodium thermocouple to 1400° or a radiation pyrometer with a thermo-element at the focus of the reflector is used for higher temperatures.

For measuring the voltage produced by a thermocouple, millivoltmeters are available. A recent development which has increased the sensitiveness of the millivoltmeter is the use of finely drawn aluminium alloy wire, insulated with enamel, for the moving element. The enamel coating is much thinner than silk insulation and more turns can be secured on a coil of given width. In addition, the weight is only one-third of the weight of a moving element made with copper wire. The author has also devised a millivoltmeter, called the Brown Heat Meter, practically identical with

the Northrup pyrovoltmeter (see preceding abstract), which obviates the errors caused by the resistance of the leads and the temperature changes in the voltmeter. The Brown heat meter, however, is also designed to overcome spring fatigue.

By the introduction of suitable switches, a record of the temperature of quite a number of thermocouples can be made on the same chart.

The author describes a method of automatic temperature control. The pointer of the millivoltmeter, depressed by a means first discussed in U.S. patents by Brewster in 1887, is made to pass over adjusted contact sheets. Contact with the sheets sets up an electric circuit, by means of which a solenoid is worked. The solenoid regulates the heating of the furnace by operating valves in the case of gaseous or oil fuel, or switches in the case of electrical heating. In a similar manner, automatic temperature signalling by means of red, white, and green lamps can be carried out.

The difficulty of this automatic control lies in the fact that the necessary sensitiveness of the indicator pointer makes it very susceptible to disturbances.

In the discussion which followed the reading of the paper, Mr. R. Whipple mentioned several cases in which automatic temperature control was being successfully carried out at the present time.

J. D. C.

191. Pyrometry Applied to the Hardening of High-speed Steels. J. O. ARNOLD (*Trans. Faraday Soc.*, 1918, **13**, 271).—The author has had much experience in the use of five types of pyrometers for determining the temperature of hardening baths. A description is given of the pyrometers, which were: (1) Féry radiation, (2) Féry spiral, (3) Foster base-metal thermocouple, (4) Leskole optical (modified Wanner), and (5) Mésuré optical.

All five worked very successfully at 1300°. It should be noted that very good black-body conditions existed.

J. D. C.

192. Pyrometer Standardisation. E. GRIFFITHS and F. H. SCHOFIELD (*Trans. Faraday Soc.*, 1918, **13**, 222).—The object of the paper was to indicate the basis of the temperature scale of the practical type of pyrometer, and also to set out some of the errors to which pyrometric observations are liable.

It is now generally agreed that the standard scale of temperature should be the thermodynamic. The scale of the constant volume nitrogen thermometer agrees within the limits of experimental error with the thermodynamic up to 1000°. The constant volume hydrogen scale and the platinum resistance scale also agree closely at fairly low temperatures. By means of gas thermometers and thermo-elements standardised against gas thermometers, a large number of boiling, freezing, and melting points in terms of the thermodynamic scale have been determined, ranging from -183° to 1550° . These temperatures form the "fixed-point scale." A list of suitable fixed points is given by the

authors, and to bridge the gap between the melting point of copper, 1083° , and of nickel, 1452° , the use of a nickel-carbon eutectic melting at about 1330° is suggested. This eutectic is formed by melting nickel with excess of graphite.

Thermoelectric pyrometers are usually standardised by employing the fixed-point scale or by heating in a suitable electric furnace alongside a standardised thermocouple. The chief sources of error in thermocouples are: (1) Liability to contamination, (2) lag, and (3) oxidation. A convenient method for detecting contamination of platinum thermocouples was described.

Resistance pyrometers, suitably sheathed, can be used successfully up to 1000° , their greatest defect being the time lag. Calibration at three temperatures only is necessary, the temperatures to be observed being then calculable from a formula.

Total radiation pyrometers are calibrated by sighting at a plug of refractory material heated in a suitable, enclosed furnace. The authors describe such a furnace. The temperature of the refractory plug is measured by means of a thermocouple stretched across it.

The chief source of error with radiation pyrometers is that the temperatures to be measured do not always conform to black-body conditions. These pyrometers are of very limited use with molten metals, since such surfaces can never be freed from haze or fog, and radiation from the walls of the furnace reflected at the molten surface is apt to introduce serious errors. They have, however, the advantage over the optical pyrometer in that they can be made to give continuous records.

Optical pyrometers are calibrated in a similar way to total radiation pyrometers. A method of calibration for routine work was described by the authors. Errors due to departure from black-body conditions are not so serious in using these pyrometers. If, however, the filter glasses are not fairly monochromatic, the personal equation of the observer is appreciable.

In the discussion which followed the reading of the paper, the use of the following standards for the fixed-point scale was suggested, namely, the iron carbide eutectic point, 1130° ; the freezing point of Cu_3Sn , 738° ; and the A 1, 2, 3 point of a commercial steel containing 1.1 to 1.2 per cent. of carbon and 0.5 per cent. of tungsten, 738° .

J. D. C.

193. The Advantage of Burying the Cold-junction of a Thermocouple as a Means of Maintaining it at a Constant Temperature. R. S. WHIPPLE (*Trans. Faraday Soc.*, 1918, 13, 253).—In works practice, the cold-junction of a thermocouple is often placed, together with a mercury thermometer, in a thermos flask containing oil, in order to maintain the cold-junction at a fairly constant low temperature.

As an alternative and suggested improvement, the author recommends burying the cold-junction.

The introduction of Peake's compensating leads (see British Patent Specification No. 370, 1909, and Whipple, *Proc. Inst.*

Mech. Eng., 1913, p. 729) has rendered it possible to transfer the cold-junction of platinum alloy couples to a considerable distance from the head of the pyrometer, so that the employment of a buried cold-junction with the rare-metal couples is rendered commercially possible. With base-metal couples, such as (1) nickel, nickel-chromium, (2) iron, nickel-copper, or (3) copper, nickel-copper, the materials are not expensive, and their use at once opens up the possibility of the method now advocated.

The author describes satisfactory results obtained with a cold-junction buried together with compensating leads 10 feet below the ground. A suitable method for burying the cold-junction is described, and an account given of its successful application to a small furnace in works practice.

In the discussion which followed the reading of the paper, it was pointed out that the possible thermoelectric effect at the terminals where the wires leading down to the buried cold-junction are connected to the wires leading either to the thermocouple or to the galvanometer introduces a serious difficulty. With the use of Peake's compensating leads the trouble is not so great. This thermoelectric effect will be greater if the terminals get warm, and must be guarded against. The suggestion was made that with large furnaces it would be necessary to bury the cold-junction 40 feet below the level of the furnace.

J. D. C.

194. Optical Pyrometry in Non-ferrous Metallurgy. F. G. DONNAN (*Trans. Faraday Soc.*, 1918, 13, 276).—The author quotes results of emissivity measurements of solid and molten copper, silver, and gold, and shows that the radiation from these metals is less than the radiation from a "black-body" at the same temperature. Consequently, temperature readings of these metals with an optical pyrometer are low, and a correction must be applied.

In general, optical pyrometers cannot be used for good reflecting surfaces without applying a correction.

J. D. C.

195. The Determination of the Temperature of Liquid Steel under Industrial Conditions. COSMO JOHNS (*Trans. Faraday Soc.*, 1918, 13, 280).—In the author's experience, the most useful pyrometer for determining the temperatures of liquid steel is an optical pyrometer, using monochromatic light $\lambda = 0.65 \mu$, which, it is suggested, should be adopted as a standard. The apparent temperatures observed with the pyrometer have to be corrected, owing to the emissivity of the liquid steel being less than unity. A table of corrections for different emissivities at different temperatures is given, and the conditions under which temperature readings are best taken are stated.

J. D. C.

196. Notes on Pyrometry from the Standpoint of Ferrous Metallurgy. W. H. HATFIELD (*Trans. Faraday Soc.*, 1918, 13, 289).—The difficulties of pyrometry in steel works prac-

tice are outlined, and the pyrometers best suited, in the author's opinion, for the different operations are stated. J. D. C.

197. Applications of Optical Pyrometry in Steel Works Practice. J. N. GREENWOOD (*Trans. Faraday Soc.*, 1918, 13, 295).—The various conditions of use of optical pyrometers in measuring the temperatures of liquid steel in the open differ widely from the calibration conditions, and therefore the temperatures read are only apparent temperatures and below the real values.

The errors fall into two classes, according to whether they are or are not accurately determinable. To the first class belong errors due to emissivity and polarisation of the emitted light. To the second class belong such as are due to monochromatism of the absorbing screen (absent in such types as the Wanner), to fumes, to light reflected from external sources, and to smallness of the object sighted at.

All the above points are dealt with fully by the author. The difficulty of obtaining good monochromatic red glass in this country is mentioned. Technical defects in present optical pyrometers were considered, and a suggestion made that in order to obtain control of steel-making pyrometrically, a refractory tube should be inserted into the bath when it is required to take temperatures, thus approaching nearly to black-body conditions.

In order to overcome the error due to the polarisation of emitted light, the pyrometer should be sighted normally at the surface of the molten material, or the instrument should be rotated axially and readings taken every 90°, the mean of the four readings being the correct apparent temperature. J. D. C.

198. Temperature Determinations of Liquid Steel. A. McCANCE (*Trans. Faraday Soc.*, 1918, 13, 309).—The author has successfully employed the Siemens optical pyrometer for temperature measurements of liquid steel. The errors introduced, due to the absorbing screen of the pyrometer not being monochromatic, are discussed and illustrated by the results of some measurements with different types of screen. J. D. C.

199. The Measurement of High Temperatures by Means of Pottery Materials. H. WATKIN (*Trans. Faraday Soc.*, 1918, 13, 330).—The author reviewed the methods of measuring high temperatures by means of the contraction and fusibility of ceramic materials.

The earliest method of utilising the contraction was devised by Josiah Wedgwood. Improvements on this were invented by the author and later by Buller.

The first widely adopted method of utilising the property of fusibility was due to Seger, who prepared a series of cones having differing fusing points over a wide range of temperature. One fault of these cones is that if they sag in the line of vision, the sagging is difficult to observe. This difficulty has recently been

overcome by a revision of the shape of the cone by Professor Cobb. Other methods utilising fusibility: (1) the Watkin heat recorder, in which pellets of fusible materials of definite composition and melting point are contained in circular recesses in a refractory block, (2) the Holdcroft thermoscope, in which bars of refractory material are suitably suspended in a refractory case, and (3) Wenger's calorites, bars of fusible material coloured at one end, the colour denoting the fusing point.

All the above thermoscopes and their operation were described and illustrated in the paper.

In the discussion on the paper it was contended that these thermoscopes are best regarded as heat-treatment recorders rather than actual temperature measurers. The sagging of, say, a Seger cone can be brought about by longer treatment at a lower temperature, or by shorter treatment at a higher temperature. The fusing points stated for the fusible parts of these thermoscopes are obtained by calibration of a two to four hours' heat. J. D. C.

200. Base-metal Thermoelectric Pyrometers. C. R. DARLING (*Trans. Faraday Soc.*, 1918, 13, 344).—The couples commonly employed are iron-constantan, two iron-nickel alloys of different composition, and two different nickel-chrome alloys, known as Hoskins's alloys. The couples chosen are such as yield a relatively high *E.M.F.*, which increases uniformly with temperature. When iron is used as one of the metals in a couple, it may be prevented from oxidising by coating with aluminium, as shown by Ruder (*Trans. Amer. Electrochemical Soc.*, 1915, 27), who has devised a process known as "calorising."

Up to the present, no base-metal couple has been brought into use capable of being used continuously at temperatures above 1000°. The object of the paper is to suggest a means of extending the range of base-metal couples by utilising the *E.M.F.* developed by a junction in which one or both the metals may be in the liquid state.

The results which the author and A. W. Grace (see *Proc. Phys. Soc.*, 1916, 19) have so far obtained indicate that in general thermoelectric properties are unaffected by fusion, and that a temperature *E.M.F.* curve shows no discontinuity at the fusion point. Exceptions to this rule are furnished by bismuth and antimony, both of which show an abrupt bend in the curve at the melting point. Bismuth and antimony, however, differ from other metals by expanding on solidification and by possessing a lower resistance to electricity in the liquid than in the solid state.

Results obtained with a lead-German silver couple above the melting point of lead were set out diagrammatically. The construction of this experimental couple was described, and the design of a suitable workshop pyrometer of this type discussed.

Owing to the war, the author had not as yet been able to develop this research.

In a written contribution to the discussion (p. 316), Dr. F.

Rogers described, with the aid of a diagram, a thermocouple for use with molten metals in which the wires of the couple are not joined at the hot junction, but connected by immersing the ends in the molten metal.

J. D. C.

201. The Relation of Optical and Radiation Pyrometry to Modern Physics. P. D. FOOTE (*Trans. Faraday Soc.*, 1918, 13, 238).—The basis of all optical and radiation pyrometry is to be found in three laws, namely, Wien's displacement law, the Stefan-Boltzmann law of radiation, and Wien's or Planck's distribution law, especially the two last-named. Optical pyrometry, in particular, depends on Wien's distribution law, to which Planck's form can be reduced under certain conditions, approximately fulfilled in practice. It states that, for any definite wave-length, the brightness of a "black body" is a function of the temperature. Methods by means of which the numerous constants involved in the above three laws can be determined are referred to. As the lamp in an optical pyrometer is not at the same temperature as the furnace, and as the red glass screen is not absolutely monochromatic, the photometric match between the lamp and the source viewed is not a colour match. Because the eye has a different sensibility for different wave-lengths, a small error is thus introduced; physiological optics has therefore a relation to pyrometry. This aspect of temperature measurement is considered, and means for minimising the error are indicated.

J. R. C.

202. The Automatic Control and Measurement of High Temperatures. RICHARD P. BROWN (*J. Ind. Eng. Chem.*, 1918, 10, 133).—Where the temperature of numerous processes must be accurately controlled, as in the glass industry and the brick industry, it is advisable that it should be controlled automatically as far as possible in order to eliminate the personal element.

Various instruments and the latest improvements are described in detail by the author. A temperature signalling pyrometer is also described which automatically signals by lights whether the temperature is too high, correct, or too low in any particular furnace.

For greater precision in temperature measurements than is secured with the high-resistance millivoltmeter, a new instrument, the Brown precision heat meter, has been developed, a description of which is given.

C. M. M.

VII.—Chemical Analysis.

203. Sampling versus Correct Analytical Results. J. B. C. KERSHAW (*Met. Chem. Eng.*, 1917, 17, 108).—The author points out that an accurate analysis of a bulk sample is useless unless the sample truly represents the bulk, and emphasises the importance of careful sampling. He enumerates the following three conditions for obtaining a fair sample.

(1) The original sample taken must be large enough to represent all portions of the bulk, and a fair proportion between large and small pieces must be maintained.

(2) The sample must be reduced by repeated crushings, mixings, and quarterings to the small quantity required for the actual test.

(3) In order to continue the crushings and quarterings up to the required degree of fineness, it is necessary to dry the sample at some intermediate stage. A wet or damp sample cannot be made to pass through a 60-mesh brass wire sieve, which should be used for the final stage of sampling.

The crushing and passing through the sieve in the last part are most important. To throw away lumps because they are too hard to grind easily is a fatal error.

J. D. C.

204. A Practical Revision of the Cobalti-nitrite Method for the Determination of Potash. R. C. HAFF and E. H. SCHWARTZ (*J. Ind. Eng. Chem.*, 1917, 9, 785).—The authors' instructions for the process are as follows:—

Weigh out a 2-gram sample of material poor in potash or 0.5 gram if rich in potash, and add 0.5 gram of ammonium chloride to the former or 0.25 gram to the latter. Transfer the mixture to a mortar, mix, and grind thoroughly. Transfer the contents of the mortar to a platinum crucible, the bottom of which has been covered with about 2 grams of calcium carbonate. Cover the contents of the crucible with another 2 grams of calcium carbonate and proceed with heating and sintering as in the J. Lawrence Smith method.

Transfer the contents of the crucible to a dish, slake, and then heat to boiling. Filter into a flat-bottomed porcelain dish and wash the precipitate three or four times with very hot water. Add to the filtrate an excess of acetic acid (5 to 10 c.c.), and evaporate on a steam-bath until no odour of acetic acid remains. Take up with a little hot water, using the precaution to wash the sides of the dish thoroughly. Now add 10 to 15 c.c. of cobalt reagent (see below) and evaporate on a steam-bath to a pasty consistency. Remove from the bath, and when the precipitate has cooled take up with about 30 c.c. of cold water, breaking up the precipitate thoroughly.

Filter through an asbestos-padded Gooch crucible, and wash precipitate once with cold water poured from a beaker.

Wash the contents of the Gooch crucible into a 400 c.c. beaker (containing an excess of standard $N/5$ -potassium permanganate solution, about 10 c.c. for each 1 per cent. of K_2O equivalent in the sample) with hot water and dilute to 250 c.c. Place on the steam-bath for about fifteen minutes or until a decided black colour appears. Acidify with 10 c.c. of sulphuric acid (1:1), and then add a measured volume of $N/5$ -oxalic acid solution to neutralise the excess of potassium permanganate. Titrate the excess of oxalic acid with the $N/5$ -permanganate. If the potassium permanganate equivalent of the oxalic acid is known, the potassium permanganate reduced by the potassium cobalti-nitrite can be found and the amount of potash in the sample calculated.

The potash factor of the $N/5$ -potassium permanganate can be found by actual determination with a weighed quantity of potassium chloride, or, according to the authors, by calculation from the lime factor as:—

CaO factor:0.0056:: K_2O factor:0.00171.

The cobalti-nitrite reagent is to be made up as follows:—

(1) Dissolve 220 grams of sodium nitrite in 400 c.c. of water.
 (2) Dissolve 113 grams of cobalt acetate in a mixture of 300 c.c. of water and 100 c.c. of glacial acetic acid. (3) Mix the above solutions and place them under reduced pressure over-night. Filter and dilute to 1000 c.c. Keep the solution in a dark bottle. Never use a solution more than two weeks old.

The method was found to give very satisfactory results with test mixtures. It is applicable to water-soluble potash.

J. D. C.

205. A Rapid Pressure Method for the Determination of Carbon Dioxide in Carbonates. W. H. CHAPIN (*J. Ind. Eng. Chem.*, 1918, 10, 527).—The principle of the apparatus sketched is very simple. The requisite quantity of the carbonate is placed in a capsule which is suspended by a thread in the neck of a distilling flask of known volume, to the side-tube of which is attached a small mercury manometer. The capsule may be of copper or any metal not displacing hydrogen from the acid contained in the flask. To keep the temperature of the apparatus constant, the bulb of the flask is kept immersed in water at the ordinary temperature. The change in pressure is read off, and by a simple calculation the weight and percentage of CO_2 are obtained. It is important to fill the flask and saturate the acid with carbon dioxide before commencing the determination.

It has been found that the accuracy of this method is equal to that attainable with the absorption method, while the total time consumed in making a determination, including weighing and calculation, need not be more than 15 minutes.

C. M. M.

Reviews.

Report of the Committee of the Privy Council for Scientific and Industrial Research for the Year 1917-18. Price 4d. Published by H.M. Stationery Office.—The report under review is the third which has been issued, and its contents indicate an expansion of the work of the Department of Scientific and Industrial Research which it is very interesting to note. Not only has the research spirit spread through a considerable number of British industries, but the United States, our Colonies, and India are all actively engaged in surveying their resources with a view to their development on scientific lines and in promoting industrial undertakings. To this end, sums of public money have already been allotted.

From the report we learn that some thirty industries are already taking active steps towards the establishment of research associations. Three such associations are already licensed, four others hope soon to complete their arrangements, whilst a further six have made considerable progress. Model documents, in which some changes have been made from those previously published, are given as an appendix, so as to serve as a guide to industries desirous of setting up research associations.

The functions of the department have undergone enlargement, and we note with interest that responsibility for the National Physical Laboratory has passed into its hands, whilst it is also stimulating research in recognised institutions by the payment of grants to students and research workers.

Glass manufacturers should seriously consider if the time is not ripe for the formation of a research association for the glass industry. The objects for which the Government is willing to provide financial assistance are various, but may be indicated by the following three of several paragraphs contained in the model draft of a research association.

“The objects for which the association is established are:—

“(a) To promote research and other scientific work in connection with the trade or industry and other trades and industries allied therewith or accessory thereto, and for that purpose to establish, form, equip, and maintain laboratories, workshops or factories, and conduct and carry on experiments, and to provide funds for such work, and for payment to any person or persons engaged in research work, whether in such laboratories or elsewhere, and to encourage and improve the education of persons who are engaged or are likely to be engaged in the industry.

“(b) To prepare, edit, print, publish, issue, acquire, and circulate books, papers, periodicals, gazettes, circulars, and other literary undertakings treating of or bearing upon the said trades or industries or any of them, and to establish, form, and main-

tain museums, collections, libraries, and collections of literature, statistics, scientific data, and other information relating to the said trades or industries or any of them, or to matters of interest to the members thereof, and to translate, compile, collect, publish, lend, and sell, and endeavour to secure, or contribute to, the translation, compilation, collection, and publication, by Parliament, Government Departments, and other bodies or persons, of any such literature, statistics, and information, and to disseminate the same by means of the reading of papers, delivery of lectures, giving of advice, the appointment of advisory officers, or otherwise.

“(c) To retain or employ skilled, professional, or technical advisers or workers in connection with the objects of the association, and to pay therefor such fees or remuneration as may be thought expedient; also to found, aid, maintain, and endow scholarships and bursaries for the remuneration, instruction, and support of students in research work, or persons engaged in studying the principles involved in any of the said trades or industries or connected therewith, whether in the laboratories of the association or elsewhere, and to employ and remunerate as may be expedient instructors and supervisors for such students, and also for persons engaged in studying the principles involved in any of the said trades or industries or connected therewith, paying due regard to the provision of instruction by existing institutions.”

Towards such research associations the Committee of the Privy Council is willing to contribute large sums of money. What are needed on the part of the glass manufacturer are a willingness for co-operation with his fellow-manufacturers in this matter and real evidence of conviction on his part by a promise to contribute a definite sum or sums towards the funds of the association. The contribution exacted from the trade is always based on its financial circumstances, and in one notable case the Government has contributed £36,000, whilst the trade has found £4,000 only. In any case, the Government is willing to grant at least £1,000 for every £1,000 found by an industry.

Some of the more enlightened glass manufacturers are already asking if it is not time that the glass industry shall take advantage of the Government's offer while it is still to be had. But what of the rest? Any movement towards the formation of a research association must come from the whole industry, and not from a section. Where do we stand in this matter? W. E. S. T.

I.—Glass-making Materials.

206. Recovery of Potash from Iron Blast Furnaces and Cement Kilns by Electrical Precipitation. LINN BRADLEY (*J. Ind. Eng. Chem.*, 1918, 10, 834).—The potash recovery plants may be roughly divided into those in which the recovered potash is the main product and those in which the potash is recovered as a by-product. In this paper the latter phase is considered, as it is believed that while the largest immediate tonnage may be obtained from desert lakes, kelp, alunite, and a few other sources, nevertheless a study of the economic problems shows that the surest way, in the author's view, of making the potash industry a permanent and enduring one is to develop and rely upon the by-product potash.

In all cases mentioned by the author, the potash is volatilised and then recovered from the gases. The Cottrell process has met with excellent success in this phase of potash recovery problems. The field of application which has been developed the farthest is in the recovery of potash from cement kiln gases.

Useful tables are included, and a bibliography is given.

C. M. M.

207. Recovery of Potash from Kelp. C. A. HIGGINS (*J. Ind. Eng. Chem.*, 1918, 10, 832).—The recovery of potash from kelp, and the utilisation of kelp ashes, principally as a fertiliser, is an art that has long been practised.

The greatest practical advance in the economical production of potash from kelp was made in 1915, when a company in America designed equipment for the production of acetone, potash, and iodine from kelp. The plant since its inception has rapidly increased the number and range of its products, and has placed upon the market some new materials which are full of industrial promise.

It appears to be evident that the kelp industry will eventually develop along the lines of fine chemicals with high-grade potassium chloride as a by-product, which is produced by a fermentation process, and not by the original method involving the incineration of the kelp.

C. M. M.

208. Potash from Desert Lakes and Alunite. J. W. HORNSEY (*J. Ind. Eng. Chem.*, 1918, 10, 838).—Investigations of all probable sources of supply of potash in America, including felspar, kelp, desert lakes, leucite, and alunite, have definitely resulted in the development of a permanent potash industry.

Descriptions of desert lakes which contain deposits of potash are given by the author.

C. M. M.

209. Potash from Searles Lake. ALFRED DE ROPP, jun. (*J. Ind. Eng. Chem.*, 1918, 10, 839).—The author gives a description of the most distinctive features of this desert basin. A description of the plant employed is also given, together with many photographs and some useful tables. C. M. M.

210. The Melting Points of Cristobalite and Tridymite. J. B. FERGUSON and H. E. MERWIN (*Amer. J. Sci.*, 1918, 46, 417).—The melting point of silica usually accepted in the past five years was that of Fenner, namely, 1625°. After reviewing previous determinations in the light of their own results when studying the system CaO-MgO-SiO₂, the authors were inclined to the view that Fenner's value was too low.

A new type of furnace was therefore devised, consisting of an inner coil of platinum with 20 per cent. rhodium wrapped on a magnesia tube, and the outer coil of pure platinum on an alundum tube, the two sections being separated by magnesia insulation.

By the aid of this furnace, the melting points, to within 10°, were determined to be: cristobalite 1710°, and tridymite 1670°. Quartz was also converted to tridymite by heating alone, and this in turn to cristobalite. W. E. S. T.

II.—Glass: Manufacture and Properties.

211. The Phosphate Glasses. FRANZ CEDIVODA (*Chem.-Zeitung*, 1901, 25, 347). The author has prepared several phosphate glasses in order to compare their durability with the corresponding silicate glasses, and with the further object of testing the formulæ ascribed to stable glasses by Zulkowski.

The first three glasses prepared had the following percentage compositions:—

	I.	II.	III.
P ₂ O ₅	70-83	78-23	82-95
CaO	13-50	8-28	5-92
Na ₂ O	15-27	10-02	7-55
Al ₂ O ₃	trace	0-30	0-37
SiO ₂	trace	1-96	2-26
MgO	—	0-14	0-33
K ₂ O	—	1-03	0-65

The presence of Al₂O₃, SiO₂, and MgO was due to action on the material of the crucible. Platinum crucibles were badly attacked, crucibles of ordinary thickness lasting for two melts only.

In order to test the resistance towards water, the glasses were powdered, sieved to a definite size (not stated), powder being avoided, and 10 grams allowed to stand with 100 c.c. of water for

twenty-four hours at the ordinary temperature. The solution resulting was analysed, with the following results:—

Glass.	Soluble matter in mg.	Composition of dissolved matter. Milligrams.			Mol. alkali per mol. P_2O_5 .
		P_2O_5 .	Na_2O .	K_2O .	
I.	371.6	261.30	57.30	—	0.50
II.	293.4	238.40	36.30	4.30	0.37
III.	100.5	84.30	8.75	0.95	0.25

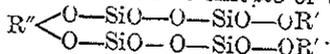
The weights are those obtained from 10 grams of the glass. The molecular proportions of alkali to P_2O_5 in the original glasses were 0.49, 0.31, and 0.22 respectively.

With a glass made from equimolecular proportions of CaO, P_2O_5 and Na_2O, P_2O_5 , there was a loss, on treatment with water as above, of 53.9 per cent. in weight, but proportionately little CaO was found in solution.

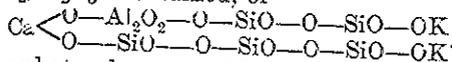
In resistance tests with 10 per cent. hydrochloric acid, carried out as with water tests, the following results were obtained:—

Glass.	Composition of dissolved matter. Milligrams.			Mol. alkali per mol. P_2O_5 .
	P_2O_5 .	Na_2O .	K_2O .	
I.	3452.0	769.6	—	0.51
II.	781.6	109.1	12.9	0.34
III.	457.8	50.1	4.7	0.26

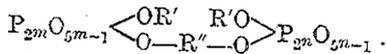
Following Zulkowski, the author assumes that the reason why a glass of the general composition $R'_2O, R''O, 6SiO_2$ shows considerable resistant power is that it is a double silicate of the type



When alumina is added, it substitutes SiO_2 , and the glass $K_2O, CaO, 5SiO_2, Al_2O_3$ is obtained, or



Double phosphate glasses would, in the author's view, be of the form

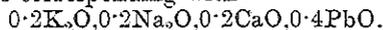


From his experiments, the author drew the conclusions that:—
 (1) True double phosphates result from the melting of the simple sodium and calcium metaphosphates, and such double phosphates are more resistant than the components. (2) The double phosphates are the more resistant the greater the proportion of acid contained. (3) The phosphate glasses are less resistant than the corresponding silicate glasses. (4) With silicate glasses, water removes alkali mainly; with phosphate glasses, phosphoric acid also. (5) Phosphate glasses are very much more strongly attacked by acid than the corresponding silicate glasses. (6) The phosphate glasses are much more fusible than the silicate glasses. (7) Porcelain crucibles can be employed to melt phosphate glasses.

W. E. S. T.

212. Phosphoric Acid Glasses and Glazes. HELENE FRITZ (*Ker. Rundschau*, 1918, 26, 195).—A study of various glasses in which phosphoric oxide is the only acid radicle present. Two series of experiments were made, in which the phosphoric acid was introduced as phosphoric anhydride and as metallic phosphates respectively. The various mixtures were melted in small crucibles in a muffle kiln heated to about S.K. 03a (1040°).

In the first series, three types of glass were studied, namely: (a) High lead and low alkali, the bases corresponding with the molecular ratio $0.1K_2O, 0.1CaO, 0.8PbO$. (b) Low lead and high alkali, corresponding with $0.3K_2O, 0.4Na_2O, 0.1CaO, 0.2PbO$. (c) An intermediate type corresponding with



Seven melts were made with each of these types, the alumina and phosphoric acid contents representing:

- | | |
|-------------------------------|---------------------------------|
| I. $1.0P_2O_5$. | IV. $2.0P_2O_5, 0.2Al_2O_3$. |
| II. $1.0P_2O_5, 0.1Al_2O_3$. | V. $3.0P_2O_5$. |
| III. $2.0P_2O_5$. | VI. $3.0P_2O_5, 0.3Al_2O_3$. |
| | VII. $3.0P_2O_5, 0.15Al_2O_3$. |

The batch compositions for the twenty-one melts are given, and the results of the melts expressed diagrammatically. All the glasses show high refraction. As is the case with silicate glasses, the most brilliant glasses are those with a high lead content. The alumina does not appear to exert a favourable influence on the fusibility, especially in the glasses high in phosphoric acid.

Some of the glasses were affected by exposure to air, namely, aIII and aV slightly, cIII, cV, and cVII rather more, and bIII and bV strongly.

The least resistant glasses are those with high acid content, whether they contain little or no alumina in proportion to acid.

The various glasses were finely ground and applied as glazes to a stoneware body containing 7 per cent. of magnesite, and afterwards burnt to S.K. 03a. Apart from the series richest in lead, the most brilliant glazes were those with high acid content. Brownish-grey specks appeared in many of the trials, but were absent from the high lead series. The resistant qualities of the glazes were tested (a) by boiling for one hour in water, (b) by boiling for half an hour in a 4 per cent. acetic acid solution.

With water, aV and cV were slightly attacked, all the others remaining good. With acetic acid cV became matt, aV, bV, and aI were distinctly, and bVII, cIV, and cVI slightly attacked.

These results show that it is quite possible to make phosphate glasses, and that such glasses with high lead content and low acidity are the most durable.

In the second series the glasses were of the types: I. $RO, 0.33P_2O_5$, II. $RO, 0.58P_2O_5$, III. $RO, 0.66P_2O_5$.

In group I, RO was represented by $0.5PbO$ associated with $0.5PbO, K_2O, Na_2O, BaO, ZnO,$ and CaO , respectively.

In group II, RO consisted of $0.3Na_2O, 0.3K_2O,$ and $0.3PbO$, together with $0.1PbO, ZnO, BaO,$ and CaO , respectively.

In group III, the bases were $0.5K_2O$, $0.4PbO$, together with $0.1PbO$, CaO , ZnO , and BaO , respectively.

The batch mixtures for the fourteen glasses are given, and the series was repeated with the addition in each case of $0.15Al_2O_3$.

Many of the glasses, both with and without alumina, appeared crystalline. The alumina exerted a slight, but distinctly favourable, influence on the melting, and assisted in attaining plain metal. None of these glasses showed the susceptibility to atmospheric attack observed in the more strongly acid series.

These glasses were ground up and used as glazes, as with the previous series. Here the influence of alumina on the fusibility was more marked, the aluminous glazes being in general softer. None of the glazes showed signs of crazing.

As regards the effect of the different basic oxides on the fusibility of the glazes, the order is as follows:— PbO is the most fusible, and Na_2O has nearly the same effect. K_2O and BaO follow in the order named, and lastly come CaO and ZnO , which have practically the same effect.

J. H. D.

213. Studies on the Composition and Properties of Phosphate Glasses. O. INWALD (*Inaugural Dissert.*, Berlin, 1900; *Chem.-Zeitung*, 1901, 25, 1058).—The author found that normal glasses only dissolve calcium phosphate in considerable quantities at very high temperatures, and that on cooling the dissolved phosphate is precipitated, producing a turbid or opalescent appearance. In normal glasses, phosphoric acid can only substitute silica to the extent of 0.025 molecule. In order to obtain calcium phosphate glasses at low temperatures, therefore, easily melting glasses must be used, either with alkali or boric oxide as pronounced constituents.

The ordinary lime-soda phosphates were found to dissolve to a greater extent in water than the corresponding silicates. Boric oxide increases the resistance of phosphate glasses.

The usual assumption that in phosphate enamels the calcium phosphate is in suspension was confirmed.

W. E. S. T.

214. Composition of Mirror Glass in France and Elsewhere. (*La Ceramique*, 1903, 33, 111).—The general composition of mirror glass, both in France and in other places, is the same, being principally made to resist the action of the air. It is, however, interesting to note the slight differences employed in order to obtain special kinds of glass. The following table gives the percentage composition of some glasses actually in use in the various countries:—

	France.	England.	Germany.	Belgium.	Russia.	United States.
SiO_2	74.30	74.16	74.30	73.44	74.16	71.41
CaO	12.29	12.33	12.29	13.02	12.33	12.26
Na_2O ...	13.41	13.54	13.41	13.54	13.54	16.33

In every case except that of the United States, the soda is present in the batch as sulphate. In this exceptional case it is chiefly pre-

sent as carbonate. This glass also contains a trace of arsenic, whilst the percentage of soda has been increased at the expense of the silica, so that the amount of alkali present is greater than represented by the normal formula, $6\text{SiO}_2, \text{CaO}, \text{Na}_2\text{O}$. This may be due to a desire for quicker melting and the resulting increased production, but the effect is to lessen the resisting power of the glass. The proportional increase of lime also increases appreciably the tendency of the glass to devitrify when heated. In the opinion of the American manufacturers, the addition of arsenic (about 0.7 per cent.) gives the glass a certain homogeneity very desirable in mirror glass.

J. R. C.

215. The Dulling of Window Glass. M. STOERMER (*Spezial*, 1901, 34, 1173).—When a manufacturer finds that the batch mixture he is using does not produce a satisfactory glass, the composition should not be altered arbitrarily, but from information gained by tests in the laboratory. For example, a high alkali glass, though it saves time and fuel, does not resist the action of the weather, and if used for windows soon becomes dull. Weber has shown that a trisilicate with equal molecular amounts of soda and lime gives a glass which resists weather satisfactorily. The author shows how he altered a manufacturer's batch formula in order to produce a good window glass. The original proportions were: sand, 160; salt-cake, 80; limespar, 50; coke, 5. The resulting glass soon became dull, so the quantity of salt-cake was reduced to 75, giving a molecular ratio sand:lime:alkali of 5:32:1:1. A good glass was the result, but the time taken to melt it was too long and it was difficult to work. Potash was therefore molecularly substituted for soda, in stages, until the formula recommended was: sand, 160; limespar, 50; salt-cake, 70; potash, 6; coke, 4. This batch melted as quickly as the original and was more durable.

The author urges manufacturers to modify their formulae on scientific principles.

J. R. C.

216. The Fusibility of Silicates and Borates used in Glass Manufacture. A. GRANGER (*Moniteur Scient.*, 1902, 16, 81).—A law connecting the chemical composition of a substance with its fusibility would be very useful in glass manufacture. By consideration of the composition and melting points of Seger cones 15, 18, 26, 27, 28, it is seen that the fusibility of silicates decreases (1) by increasing the acidity; (2) by introducing a larger quantity of alumina; (3) by diminishing the amounts of the alkalis and alkaline earths. However, there is no simple relation by which the composition and fusibility are related. The author gives an account of the "refractory quotients" of Bischoff, Seger, and others, and finally arrives at the expression $q = T^2/173.4FK$, where q is the refractory quotient, K the silica content, T the alumina content, and F being equal to $\left(\frac{A}{M_a} + \frac{B}{M_b} + \dots\right)A, B, \text{etc.}$,

being the percentages of fluxing oxides, and M_a , M_b their molecular weights. This formula also is subject to modification, and the whole question is admitted to require further investigation.

J. R. C.

217. The Effect of the Degree of Smelting on the Properties of a Frit. E. P. POSTE and B. A. RICE (*J. Amer. Cer. Soc.*, 1918, 1, 221).—This paper deals with the comparison between the actual composition of the resulting frit and the theoretical composition as shown by the computed formula. It is assumed that at some particular stage in the smelting of an enamel the actual composition corresponds with the theoretical composition. Hence it follows that there must be two stages, one on either side of this particular point, during the first of which there are still present some of the materials which are volatile in the ordinary sense of the term, and beyond which point further heating may possibly cause decomposition and volatilisation of some of those materials which are ordinarily considered as being non-volatile.

In general, it is concluded that the chemical composition of a frit at the point of normal pouring may differ quite materially from the composition which would be expected based on theoretical computation. The principal differences in the case under investigation were noted when the SiO_2 content was materially higher, the Al_2O_3 , CaO , and K_2O were slightly higher, and the Na_2O and B_2O_3 contents very much lower than the theoretical composition would indicate. Prior to this point, the batch as a whole passed through a stage approximating the computed composition, with the exception of the B_2O_3 content. Further heating produced very marked chemical changes. Thus, assuming the SiO_2 to remain constant after the volatilisation of the silicon tetrafluoride, there was a slight volatilisation of CaO , Al_2O_3 , and K_2O , and very marked losses of B_2O_3 and Na_2O .

As a result of these chemical changes, an objectionable rise in the maturing point of the enamel is introduced, but a favourable increase in the deformation range is observed. C. M. M.

218. Media for Decolorising Glass. C. JUNG (*Sprechsaal* 1902, 35, 1493).—Fewer decolorisers would be needed if more attention were paid to the purity of the raw materials and to the heating of the furnace. Of the decolorising agents most frequently used, antimony has the least effect. Its only action is to colour the glass a very faint blue, which modifies the green due to iron. Manganese is a powerful colouring material, and only very small quantities are necessary to neutralise the iron green. According to the author, manganese and arsenic should not be used in the same batch, as then the glass is coloured violet. Nickel should be used in this case. It is the safest decoloriser and it works equally well with potash and with soda glasses. A mixture of 8 per cent. of nickel oxide with 92 per cent. of manganese oxide is stated to

work very well. Selenium is the strongest decoloriser, but its effect is so uncertain that its use is not recommended. J. R. C.

219. Procedure for Colouring Glass. M. MEURER (*Monit. Ceram.*, 1901, **32**, 105).—The author advocates the use of carbon for colouring glass yellow, brown, red, or black. It should be added in the form of powdered and dried lignite. It is very much cheaper than the manganese usually employed for this purpose. J. R. C.

220. Defects in Glass. C. JUNG (*Sprechsaal*, 1901, **34**, 1575).—A summary is given of the defects in glass which arise during the melting process. If the furnace is not hot enough, the gases evolved (for example, carbon dioxide, sulphur dioxide, water vapour) cannot escape on account of the viscosity of the glass, but remain as small bubbles. These can be cleared out by a high melting temperature. If the bubbles, however, are very fine they cannot be cleared. The presence of seeds decreases the resistance of the glass to fracture and also lessens its durability. This is also the case with "stones," of which there are two types. Stones of the first type are composed of unmelted batch. They are usually white and spherical. The best way to get rid of them is to stir into the metal a batch of softer composition and melt at a higher temperature. The second type of stone is very different. It is caused by small pieces of pot which have fallen from the crown. The stones are yellow or brown and have sharp edges. Glass containing stones of this kind is so brittle that it is not worth working. The remedy is to change the mixture from which the pot is made. When a pot is charged, some of the batch is liable to remain on the crown and on the sides above the level of the metal, and on melting drops into the glass and produces "cordy metal." This cannot be totally prevented, especially in small pots.

The resisting power of glass is also reduced by the presence of "streaks." These are caused when gathering. They are also produced if the glass is too cold when blown or if it is cooled too quickly when reheated for "running-on." The glass from the bottom of a pot is usually streaky, owing to the difficulty of gathering and blowing. Streaks sometimes arise from bad batch composition; an excess of lime gives rise to them.

If salt-cake is used as the source of soda, blue spots are occasionally to be observed in the glass. These are due to undecomposed sulphate which has been absorbed by gas bubbles and retained through the viscosity of the glass. They are commonly known as "glass-gall." J. R. C.

221. Coloured Glass for Medicine Bottles. H. J. MÖLLER (*Chem.-Zeitung Repertorium*, 1900, **24**, 5).—The author, following up some chemical tests, has made spectroscopic examinations of

differently coloured medicine bottles, and drawn the conclusion that the colours which best afford protection from the action of light on medicines are dark brown, dark green, and especially red.

W. E. S. T.

222. On the Changes Produced in Solutions of Medicines Contained in Glass Bottles. A. DIAN (*Chem.-Zeitung Repertorium*, 1900, 24, 5).—The author points out that the changes produced in medicines, especially solutions of alkaloids, whereby crystals are deposited and the liquid rendered turbid, is to be ascribed to the action of glass of poor quality containing high soda proportions. A harder glass, though more difficult to work, is better for bottles to contain medicines.

W. E. S. T.

223. The Colour which Iron and Manganese Compounds impart to Glass. C. DRALLE (*Sprechsaal*, 1901, 34, 68, 103; *Chem. Zeitung*, 1900, 24, 1132).—In the author's experiments, iron and manganese compounds were added to a lime-soda batch, the soda being present as sulphate when it was desired that the colouring agent should be in the lower stage of oxidation. The batches employed were as follows:—

I.		II.	
Sand	685	Sand	685
Limespar	285	Limespar	285
Soda-ash.....	260	Salt-cake.....	400
Soda-nitre	65	Wood-charcoal	20

These batches should give glasses of the composition 68·2 per cent. SiO_2 , 15·4 per cent. CaO , 17·3 per cent. Na_2O . Special care was taken to get the raw materials as pure as possible, and analyses showed that the actual percentage compositions of the glasses produced from the standard batches were:—

I.		II.	
SiO_2	66·36	SiO_2	68·87
Al_2O_3	2·94	Al_2O_3	2·70
Fe_2O_3	0·23	FeO	0·23
CaO	16·89	CaO	14·29
Na_2O	13·58	Na_2O	13·88

In the first series of experiments, iron was the colouring agent, and was added as ferric oxide or as hydrated ferrous sulphate. From the following table, in which the results of the tests are given, it will be seen that the form in which the iron is added makes no difference. In general, when the iron is present in small quantities it exercises a greater colouring action in the ferrous state; the reverse is true when it is present in large quantities.

The melts were made on the small scale. In all cases where the iron was present as ferric oxide (Fe_2O_3) and the manganese as manganic oxide (Mn_2O_3), the weight of batch used was 318 grams; in all the other cases 350 grams.

No. of Glass.	Percentage of iron in glass as		Colour of glass.
	FeO.	Fe ₂ O ₃ .	
1	—	0.23	Almost colourless. Greenish-blue in thick layers.
2	0.234	—	As 1, but more transparent.
3	—	0.48	Light sea-green.
4	0.46	—	Bluish-green.
5	—	0.73	Bright sea-green.
6	0.682	—	Greenish-blue. Clearer than 5.
7	—	1.00	Similar to 5, but darker.
9	0.927	—	Greenish-blue, but darker than 6.
11	1.107	—	Bright bluish-green.
12	—	1.23	Bright yellowish-green.
14	1.134	—	Bright bluish-green.
16	—	5.56	Deep yellowish-green, but still transparent.
17	5.03	—	Dark bluish-green, still transparent.
18	—	6.894	Similar to 16, but darker.
19	6.21	—	Similar to 17, but darker.
20	—	8.23	Dark olive green. Still transparent even in thick layers.
21	7.43	—	Gloomy bluish-green. Scarcely transparent in thick layers.
22	—	11.12	Similar to 20, but opaque in thick layers.
23	10.03	—	Opaque. Greenish-blue at the edges.

When manganese was the colouring agent, it was added either as manganous sulphate or as pyrolusite. A large number of melts were made, as will be seen from the following table. The difference between the colours produced under the different conditions was very marked.

No. of Glass.	Percentage of Mn in glass as		Colour of glass.
	MnO.	Mn ₂ O ₃ .	
1	—	0.071	Colourless. In thick layers there is a scarcely appreciable green tinge.
2	0.064	—	Very nearly colourless.
3	—	0.129	Similar to 1, but colour in thick layers more distinct.
5	—	0.216	Similar to 3, but the green still more distinct.
6	0.193	—	Similar to 5. Colour slightly stronger.
7	—	0.288	Similar to 5, but less coloured.
9	—	0.429	Light green tinge.
10	0.387	—	Similar to 9, but much more feeble.
11	—	0.575	Nearly colourless. Champagne-yellow tinge.
12	0.51	—	Colourless. Light grey tinge in thick layers.
14	0.644	—	Similar to 12, but slightly darker.
15	—	0.863	Similar to 13, but with violet mixed with the light grey.
16	0.776	—	Similar to 14, but darker.
17	—	1.00	Reddish-violet colour.
18	0.904	—	Champagne-yellow with grey tinge.
19	—	1.00	Reddish-violet but appreciably lighter than 17.

No. of Glass.	Percentage of Mn in glass as		Colour of glass.
	MnO.	Mn ₂ O ₃ .	
21	—	1.15	Bright violet.
22	1.02	—	Champagne-yellow.
23	—	1.29	Similar to 21, but somewhat deeper colour.
25	—	1.44	Dark violet.
26	1.29	—	Similar to 22, but deeper still.
27	—	2.15	Similar to 25, but deeper.
28	1.94	—	Light amber-yellow.
29	—	2.87	Dark violet.
30	2.48	—	Amber-yellow, with brown tinge.
31	—	4.31	Deep violet. Only transparent at the edges.
32	3.87	—	Similar to 30, but browner.
33	5.50	—	Similar to 32. Opaque in thick layers. A thick layer of sulphate separated on the top of the melt.
34	7.23	—	Similar to 33. Transparent only at the edges. Sulphate again separated from the melt.
35	6.46	—	Transparent amber-yellow. The surface of the melt was repeatedly scraped free from sulphate.
36	7.23	—	Bright vivid green. Instead of 5 parts of charcoal to 100 of sulphate, 8 parts were added to the batch. There was still a layer of sulphate on the surface of the metal.
37	7.23	—	Ten parts of charcoal. No layer of sulphate. Vivid green colour.
38	8.52	—	Colour similar to 34. Layer of sulphates as with 33.
39	9.94	—	Clear, brown in thick layers. Remarks as 36.
40	11.38	—	Similar to 39, but darker. Remarks as 36.
41	14.32	—	Darker than 40. Remarks as 36.
42	11.38	—	Greenish-yellow. Transparent even in thick layers. Remarks as 37.
43	14.32	—	Bright green. Scarcely transparent in thick layers. Remarks as 37.

A further melt was made, manganese oxide being substituted for lime to obtain a glass of the formula $5\text{SiO}_2, \text{B}_2\text{O}_3, \text{MnO}, \text{Na}_2\text{O}$. A clear, homogeneous glass was the result; it was brown, but opaque in thick layers. As it is most probable that the manganese does not exist in a glass of this composition as manganese oxide, it follows that the general effect of MnO in large quantities is to colour the glass brown.

J. R. C.

224. The Manufacture of American Opalescent Glass.

ALEXANDER (*Sprechsaal*, 1903, 36, 78).—A description is given of two glasshouses in Indiana which are devoted entirely to the manufacture of opal glass. In both cases a Boëtius furnace, which holds six pots and is heated by natural gas, is used. In the first, one such furnace is kept for white opal and another for coloured

glass, the coloured opal being produced by mixing these in a dish with a tuning-fork-shaped mixer, in order to obtain plates measuring 7 by 15 cm. In the second works, the opal is coloured in the pot. Opal glass, it is stated, cannot be made in open pots, and great care must be devoted to the firing, as the degree of opacity varies with this to a large extent. Two batch mixtures are given:

I.		II.	
Sand	100	Sand	100
Soda	35	Soda	35
Fluorspar	20	Fluorspar	40
Felspar	40	Barium carbonate	20
Red lead	5		
Saltpetre	5		

If there is any sulphur present in the fuel, the second batch should not be used, as, according to the author, the barium is very liable to react with it, imparting a yellow colour to the glass. J. R. C.

225. Alabaster Glass: History and Composition.

ALEXANDER SILVERMAN (*J. Amer. Cer. Soc.*, 1918, I, 247).—Alabaster is a term usually applied to semi-opaque glasses which transmit the light from a source, diffusing it, but not materially altering its colour. Opal glasses are also semi-opaque, but the light transmitted acquires an opal or fiery colour.

The references cited in the paper show clearly that the use of mixtures of alumina, sulphates, and chlorides with other raw materials did not originate with American chemists and manufacturers. No explanation of the cause of the alabaster effects is offered by the early writers, except that of devitrification. The author believes that sulphates and chlorides serve as ionised electrolytes in the hot liquid, precipitating various colloidal suspensions which would otherwise cause only opalescence.

In the author's researches on alabaster glass, a number of interesting facts have been established. Fluorides with alumina- or aluminium-bearing substances produce opalescence until sufficient quantities of sulphates or chlorides are introduced, when the opacifying materials gather in larger particles and white light is transmitted. The bivalent ion of the sulphates produces more intense whiteness than the monovalent chloride. This is in keeping with the behaviour of electrolytes towards aqueous colloidal suspensions.

The presence of barium compounds enhances the white colour—probably through the formation of barium fluosilicate. Cryolite produces increasing whiteness up to a certain concentration. The colour then gradually loses intensity with the introduction of larger quantities, and finally disappears. This effect resembles the solution of precipitates in aqueous solutions in the presence of an excess of the precipitant.

As a result of the author's researches, a commercially successful alabaster glass of American manufacture was placed on the market. The limited solubility of the chlorides and sulphates in the silicates

led to a considerable reduction of the quantities used in the batch with an accompanying increase in the life of the pots, which are attacked by fused chlorides and sulphates.

When alumina was replaced by its equivalent of felspar, a beautiful, speckless glass of much higher than normal viscosity resulted. Magnesium silicate also produced the alabaster effect.

The following formulæ for American alabaster glasses are contained in patents:—

(1) Sand, 100 parts; lead oxide, 15·6; soda, 21·9; nitre, 5·5; salt, 5·5; borax, 1·25 to 2·5; aluminium hydroxide, 18·12; fluor-spar, 6.

(2) Sand, 345·8 parts; litharge, 56·8; soda-ash, 86·4; cryolite, 20·0; aluminium oxide, 60·0; nitre, 32·0; borax, 8·0; plaster of Paris, 5·0.

(3) Sand, 100 parts; soda-ash, 49; red lead, 56; felspar, 120; sodium fluoride, 7·5; strontium sulphate, 1·75; sodium chloride, 5; alumina, 22·5; nitre, 5; antimonious oxide, 0·5.

Other types of alabaster glasses are given. Calcium phosphate, magnesium silicate, stannic oxide, arsenious oxide, zirconium oxide, and titanium oxide are also employed. Several batch mixtures are quoted.

A list of manufacturers of alabaster glass from 1600 to 1898 is appended, and also a bibliography of the subject. C. M. M.

226. Opal and Alabaster Glass with Corresponding Transparent and Coloured Glass for Illuminating and Decorative Use. (*Sprechsaal*, 1901, 34, 3).—A large number of batch formulæ are given which yield glasses of similar properties to those of a given opal glass. Consequently, these glasses can be used with the opal for making illuminating and fancy articles. The formulæ are appended:—

Opal glass.		Corresponding transparent glass.	
Sand	100 kg.		100 kg.
Potash	45		40
98 Per cent. soda	3		5
Bone ash	26		—
Limespar	3		15
Saltpetre	1·5		1·5
Red lead.....	1·5		1·5
Arsenic	1·5		0·5
Pyrolusite (manganese)	100 grams		100 grams
		Antimony regulus	75 „
Alabaster glass.		Corresponding transparent glass.	
Sand	100 kg.		100 kg.
Potash	56		40
Bone-ash	6	Limestone	15
Gypsum	8	Red lead	2·5
Saltpetre	3		1·5
Calcined borax	1		1·0
Pyrolusite	75 grams		80 grams
Antimony regulus.....	50		60
Tin oxide	125	Arsenic	0·5 kg.

To obtain suitable glasses of various colours, the following colouring agents should be added to the transparent batches:—

	<u>Cornflower-blue.</u>	<u>Pigeon-blue.</u>	<u>Florentine-blue.</u>
Black copper oxide	0.8 kg.	0.6 kg.	0.4 kg.
Smalt	0.4	—	0.3
Black nickel oxide	25 grams	0.3 kg.	0.3
	<u>Turquoise-blue.</u>	<u>Venetian-blue.</u>	<u>Violet.</u>
Black copper oxide	1.0 kg.	0.4 kg.	0.8 kg.
Smalt	5 grams	0.4	0.4
Green nickel oxide	—	0.2	35 grams
	<u>Moss-green.</u>		<u>Leaf-green.</u>
Chromic acid	1.5 kg.		0.5 kg.
Green copper carbonate	—		0.8 kg.
	<u>Sap-green.</u>	<u>May-green.</u>	<u>Antique-green.</u>
Barium chromate	0.8 kg.	0.6 kg.	0.5 kg.
Yellow iron oxide	0.5	—	—
Red iron oxide	—	0.4	2.2
Black copper oxide	—	2.0	—
Pyrolusite	—	—	3.3
	<u>Venetian-green.</u>		<u>Orient-green.</u>
"Verdigris"	4.0 kg.	Iron chromate	3.3 kg.
		Copper borate	2.2
	<u>Chinese-green.</u>		<u>Japan-green.</u>
Cuprous oxide	3 kg.		1 kg.
Magnetic-iron oxide	1		2
	<u>Topaz-yellow.</u>		<u>Orient-yellow.</u>
Sulphur	1.5 kg.		1.5 kg.
Antimony sulphide	2.5		2.0
Antimonite	—		1.0
	<u>Chinese-yellow.</u>	<u>Quince-yellow.</u>	<u>Anna-yellow.</u>
Antimonic acid ... 3 kg.		Cadmium sulphide 3 kg.	Uranium oxide ... 1 kg.
Ferric hydroxide 1.5		Ferric oxide 1	Antimonite..... 1
	<u>Corn-yellow.</u>	<u>Florentine-yellow.</u>	<u>Japan-yellow.</u>
Titanium nitrate 3 kg.		Titanium oxide ... 2 kg.	Potassium antimonate..... 2 kg
Lead nitrate 1		Antimonic acid ... 1	Yellow iron oxide 1.5
		<u>Venetian-yellow.</u>	
		Cadmium oxide	2.5 kg.
		Uranium oxide	0.5

227. The Manufacture of Green, Blue, and Red Aventurine Glass. ALEXANDER (*Sprechsaal*, 1903, 36, 1484).—An account is given of several experimental melts undertaken in order to obtain a good green aventurine glass. The mixture finally adopted was that given below (batch I). It melted quickly and worked out easily. Batch II was found to give a good blue aventurine glass, but a still better one was yielded by batch III:—

	I.	II.	III.
Sand	100	100	100
Soda	35	35	35
Fluorspar	15	15	15
Felspar	30	30	30
Barium carbonate.....	25	25	25
Potassium carbonate	12	12	10
Manganese	7	5	5
Cobalt	—	—	0.5
Black copper oxide	—	3	—

Care must be taken not to have too much fluorspar or felspar, or the glass will be opaque.

A red aventurine glass is very difficult to obtain, but can be produced by using the following formula. It should be melted as quickly as possible, and the glass may be opaque-red, transparent dark red, or colourless. In the last case, the red appears when the glass is re-heated:—

Sand	100	Red lead	1
Soda	32	Cuprous oxide	6
Potash	8	Ferrous oxide	3
Lime	32	Stannic oxide	3

J. R. C.

228. Thermometer Glass. G. MÜLLER (*Deut. Mech. Zeitung*, 1904, 202).—Although the glasses 16^{III} and 59^{III} are very good for mercury thermometers, there is still needed a glass which shall be available at high temperatures, for example, at 650°. The depression of the freezing point after heating, and the slow change due to variation in the volume of the bulb, depend, to some extent, on the mixing of the batch and the melting conditions. All thermometer glasses must be carefully annealed. Several directions in which further investigation is desirable are mentioned.

J. R. C.

229. The Production of Thermometer Glasses in the Jena Glassworks. E. GRIESHAMMER (*Deut. Mech. Zeitung*, 1904, 233).—The composition of different samples of the glasses 16^{III} and 59^{III} is very uniform. Only the purest materials are used, special attention being paid to the soda, which is used as carbonate, and should be free from potash. The batch is thoroughly mixed, and only one pot is in the furnace at a time, so that there shall be no danger of contamination by other mixtures. After the batch is melted, it is refined for six or seven hours. During the melting

and subsequent fining, the temperature is not allowed to rise too high, so that solution of the pot material in the glass may be avoided.

J. R. C.

230. Crystals of Barium Disilicate in Optical Glass. N. L. BOWEN (*J. Washington Acad. Sci.*, 1918, 8, 265).—The author states that in "barium crown" optical glass, especially when rich in barium, there are frequently formed in the melting furnace crystals of six-sided plates, colourless and transparent in their central portions, but surrounded by white, opaque rims. If the glass which comes from the furnace does not contain the crystals, they frequently appear on heat treatment, although the crystals may be small.

The refractive indices of the crystals were found to be $\gamma=1.613$ and $\alpha=1.595$. The optical properties did not correspond with those of any crystals hitherto described, but, by analogy with the orthorhombic symmetry of $K_2Si_2O_6$, it was considered possible that the silicate in question might be $BaSi_2O_6$. A melt was made with a mixture corresponding with this composition, and yielded crystals having the properties described.

The melting point of the barium disilicate was found to be 1426° .

W. E. S. T.

231. Some Methods of Testing the Durability of Optical Glass. E. ZSCHIMMER (*Deut. Mech. Zeitung*, 1903, 53).—When glass which is not durable is exposed to the air, in time it becomes covered with small liquid drops or white crystals. Again, if a polished flint glass surface is touched with a damp finger, it may be permanently spoiled by the formation of spots. Prolonged contact with water produces, with many glasses, a coloured iridescence or a brown appearance. If the surfaces of an optical system are thus affected, the performance of the system will deteriorate very considerably. It is necessary, therefore, to have methods by which the variation of the surface can be predicted, so that the glasses may be graded.

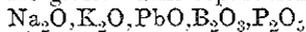
It has been shown that glasses which behave in the manner first mentioned also exhibit this appearance after being exposed to steam at a high temperature. The autoclave thus provides a measure of the liability of the glass to change in this way. The action of the moist finger is due to its slight acidity. The glasses are graded with respect to this effect by comparing the intensities of the spots produced in twenty-four hours by a drop of a solution of 0.5 per cent. acetic acid and 0.05 per cent. glycerine. Many glasses are affected by contact with water, though they are not hygroscopic. Half of the polished surface of a plate of the glass is therefore immersed in water or two or three days, and the appearance contrasted with the unaffected part.

J. R. C.

232. Observations on the Disintegration of Glasses of Different Composition under the Action of Air and Dust. E. ZSCHIMMER (*Chem. Zeitung*, 1901, 25, 780).—The appearances

exhibited by the plane polished surfaces of 200 specimens of optical glass were microscopically studied. They had been kept in a loosely covered box, in a dry place, for periods ranging up to seven years. It was found that from the disintegration appearance of the surface the character of the composition of the glass could be stated, and, on the other hand, the change of the surface could be predicted from the composition. Whilst the nature of the alteration is characteristic of the qualitative type of the composition, the degree of alteration depends on the quantitative composition. The author divides the glasses examined into three groups, namely, *A*, silicates and borosilicates (with boric oxide content up to about 20 per cent.); *B*, silicoborates and borates containing more than 20 per cent. B_2O_3 ; *C*, phosphates. He further subdivides *A* into (1) lead-free and (2) lead-containing glasses, these being again classified as (*a*) alkali-free and (*b*) alkali present.

The disintegration to be observed under the microscope or with the naked eye is first considered. The author describes two types. The first is a disintegration of the glass which affects the whole surface uniformly, and the second a mottled disintegration only appearing in the neighbourhood of dust particles which have settled on the surface. The former is called "homogeneous disintegration" and the latter "dust disintegration." The homogeneous disintegration depends on the composition of the glass, and arises from the separation of certain (chiefly hygroscopic) bases or acids from the surface of the glass. This separation of



takes place uniformly over the surface and increases with time. Potash separates as potassium carbonate, which, being deliquescent, causes the surface to be covered with a large number of small drops. If soda is the predominating alkali, sodium carbonate appears, and this is only slightly deliquescent. The surface is therefore covered with crystals. Phosphoric acid on separating out produces a similar appearance to potash. The surface layer of a glass containing boric acid absorbs water from the air, but remains unaltered in appearance until it is heated to 170° , when the surface film splits off. Dust disintegration depends not only on the glass, but on the nature of the dust particles. If these are hygroscopic, moisture accumulates where they have settled and attacks the glass; organic particles exercise a reducing action on the glass. The result is that the glass is covered with patches, and the microscope shows these to be due to "disintegration halos" surrounding minute dust particles. These halos have much the same appearance as the homogeneous disintegration phenomena. In one case fine, needle-shaped crystals of sodium carbonate radiated from the dust particle and could be detached. The "lead spots" known to opticians are caused by dust disintegration. The moisture condensed by the dust attacks the glass, dissolving out alkaline salts. The lead oxide thus liberated is then reduced by the organic particle to lead, or it may be that sulphuretted hydrogen in the

air converts the oxide into lead sulphide, which forms the black film. With alkali-free lead glasses, a direct reduction of the glass by the organic dust particle appears to take place.

As previously stated, there is a connection between the composition of a glass and its liability to disintegrate. In the case of lead-free silicates, it depends on the alkali content. As soon as a definite percentage of alkali is present, it appears on the surface, and the separation increases with the alkali content. It is appreciable when the glass contains about 10 per cent. of soda or potash. The author states that he did not find lime or zinc oxide hindered the separation. On the contrary, as they increased the alkali content, the disintegration was increased. High barium glasses exhibit dust disintegration. The increase of the liability to disintegrate with the percentage of alkali, in the case of lead glass, varies according to the lead content. As this increases, so does the disintegration. Lime and zinc oxide, again, have no preventive effect. The disintegration of borates and silico-borates is of a completely different type. It is concluded that the maximum boric acid content of a lead-free glass which shall be durable lies between 30 and 40 per cent. B_2O_3 . When lead is present in a borate glass, homogeneous disintegration, producing a uniform iridescence, is observed when more than 20 per cent. of PbO is present. This iridescence cannot be removed by grinding away the top layer, and it is ascribed to the separation of extremely fine lead spangles throughout the glass. It is probably due to the action of light. Heat increases the effect.

In general, it may be said that alkaline silicate glasses absorb moisture and deliquesce, and alkaline borates absorb moisture but remain dry. The latter are thus more durable than the former. In this connection, it is pointed out that the Jena chemical glasses are borosilicates. The phosphate glasses are all hygroscopic, and the observed phenomena are very similar to those to be seen in the case of alkaline silicates. The separation of phosphoric acid, however, produces a characteristic crystallisation which is unmistakable.

The paper is illustrated by photographs of the disintegration of various specimens.

J. R. C.

233. Action of Hydrofluoric Acid and Fluorine on Glass.

H. MOISSAN (*Compt. rend.*, 1899, 129, 799).—Hydrofluoric acid was found to attack dry glass vigorously at the ordinary temperature. The acid used was quite free from moisture, and the glass was found to lose in weight, therefore this attack is not dependent on the presence of moisture. Liquid fluorine, obtained at -187° , was found to be without action on glass at this low temperature, and when the gas was obtained by the electrolysis of a hydrofluoric acid solution of potassium fluoride, and freed from all trace of hydrofluoric acid, it was inactive towards glass. Fluorine was kept, without action on the glass, for two weeks. The gas was found to be without action, even at 100° , but the slightest trace of hydrofluoric acid or of organic matter on the glass (liberating hydro-

fluoric acid when attacked by the fluorine) caused an immediate attack.

V. D.

234. The Action of Alkalis on Glass. F. JONES (*Mem. Manchester Lit. and Phil. Soc.*, 1902-3, 47, 1).—The author investigated the action of lime and baryta-water on green glass bottles such as Winchester quarts, and on finely divided silica and powdered glass placed in the bottles. After standing for a week with occasional shaking, it was found that (a) lime-water, in contact with the glass of the bottle only, loses strength much more rapidly than baryta-water, (b) lime-water combines with silica more rapidly than baryta-water.

In all experiments in which powdered glass was in contact with alkalis, a precipitate was formed, the lime-water producing a large and the strontia and baryta-water a much smaller quantity.

It was concluded that all three solutions act on silica, lime to the greatest extent and baryta least. None of the solutions exerted any appreciable action on glass bottles during a few hours, but on prolonged contact there was a marked action in the case of lime-water.

V. D.

235. The Action of Certain Gases on Glass in the Neighbourhood of Heated Metals. G. T. BELLBY (*Chem. News*, 1904, 90, 180).—In a former paper, the author has described the formation of halos round pieces of metal foil on glass plates when heated to a sufficiently high temperature in the presence of the products of combustion of coal gas and air. The form of the halos and the formation of a corresponding image of the foil on the glass plate resting on it suggested that the effects were produced by particles thrown off from the hot metal. The halos consisted of decomposition products of the glass itself, and the agent in the decomposition was seen to be one of the gases of the surrounding atmosphere. Experiments at 500—600° showed that air dried and freed from carbon dioxide, or even dry carbon dioxide, produced very faint halos, while air containing a high proportion of sulphur dioxide and moisture produced a white film on all parts of the glass exposed, the combination taking place with such freedom that the accelerating action of the hot metal was relatively small. With sulphuric acid vapours the attack on the glass was very distinct; hence it was due to the sulphur trioxide, and this explains the white film produced on glass heated in gas furnaces or muffles above a certain temperature. This film is often mistaken for devitrification of the glass, but a microscopic examination shows it to be finely granular, not crystalline.

The formation of sulphur trioxide seemed to be determined by the presence of the hot metal throwing off ions playing the part of nuclei, whilst the products of combustion seemed to carry with them sufficient nuclei to guarantee the formation of the trioxide.

V. D.

236. The Mechanical Action of Gelatine on Solids, especially on Glass. L. CAILLETET (*Compt. rend.*, 1902, 134, 400).—If glass be covered with a thick coating of glue, thin scales of the glass are removed from the surface by the glue, which detaches itself on drying, and the glass becomes engraved, resembling panes coated with frost. The effect is easily produced on hardened glass, polished marble, calcspar, fluorspar, or rock-crystal. On glass the design is curvilinear, while on rock-crystal it is rectilinear. When salts such as potassium alum, sodium hyposulphite, and potassium chlorate, having no chemical action on gelatine, are dissolved in it, and the glue is then applied to glass, fern-like designs are produced on the removal of the glue on drying. That a great force is exerted as the gelatine contracts is shown by the curvature of sheets of cardboard, lead, or metallic gauze covered with a coating of glue, and the force is sufficient to crush a thin glass cylinder treated in this way. On examining a block of glass coated with gelatine by polarised light, it was found to be subject to a considerable stress which could be measured. V. D.

237. The Electrochemical Determination of the Attack on Glass. F. HABER and H. SCHWENKE (*Zeitsch. Elektrochem.*, 1904, 10, 143).—The object of the investigation was to ascertain whether the attack by water on a glass bottle or flask could be measured electrochemically, and, if so, to find a method whereby it could be done quickly and by persons without a knowledge of chemistry.

The methods of measuring the attack which have been hitherto employed were discussed in detail. As preliminary, directive experiments, a series of bottles and flasks was tested by the iodococin method of Mylius and Foerster, and the authors state their results.

The principle of the electrochemical method is the measurement of the change of the resistance of the water. The electrodes used were two sheets of platinum foil, 70 square mm. in area, placed 6 mm. apart. The leads were enclosed in a glass tube which had been made impervious to attack by the water by previously treating it with steam. The resistance capacity of the arrangement was ascertained by using *N*/100-potassium chloride. In the first instance an alternating current was employed, but it was replaced by a direct current. The glass was carefully cleaned and filled with conductivity water, and heated to 80° for five-hour periods. Carbon dioxide-free air was bubbled through the water to prevent contamination by the atmosphere. The resistance was measured hourly, potential differences of 10, 20, and 30 volts being used. By this triplicate measurement, the polarisation effect and the heating effect of the current could be eliminated. If k_0 is the initial specific conductivity, k_t the value after t hours, then the quantity $K = (k_t - k_0) \frac{\text{Volume of water in c.c.} + k_t}{\text{Area covered in sq. cm.}}$. The ratio $\frac{K}{t}$ was found to be constant during the five-hour periods, but decreased irregularly when the water was renewed. It varied with the composition of the glass and with its previous history. If R

is the amount of substance dissolved from the glass expressed in milligrams of Na_2O , then $\frac{E_t}{k_t - k_0}$ is constant for all the glasses.

The Jena flask was the least affected, but some of the other glasses (green and brown wine bottles) showed only a slightly greater attack. The statement that the reaction is autocatalytic is not confirmed by its linear relation to the time. Alkali alone is not dissolved, as was seen from the relation between the amount of dissolved matter and the conductivity.

The authors concluded that the method is quicker and more convenient than the chemical method and gives equally good results.

J. R. C.

238. The Attack of a Glass Batch on Pots. (*Sprechaal*, 1901, 34, 76).—The batch in question contained salt-cake, and in a discussion on the reason for the attack it was stated that salt-cake always has a greater effect than soda. The addition of charcoal up to 6 per cent. of the batch mixture, in addition to clearing the glass, reduced the attack. Quick melting was also recommended. The following mixture was stated to be suitable for pot making:—raw clay, 22 parts; burnt clay, 13 parts; potsherd, 13 parts.

J. R. C.

239. The Connection between the Electrical Properties and the Chemical Composition of Different kinds of Glass. A. GRAY and J. J. DOBBIE (*Proc. Roy. Soc.*, 1898, 63, 38; 1900, 67, 197).—In 1884 the authors found that the specific resistance of a glass increases with the percentage of lead oxide and with the density. They also observed that the conductivity is doubled for every 9° rise in temperature. The present investigation was undertaken to ascertain whether, by increasing the amount of lead and diminishing the soda, the conductivity would continue to decrease. The results of the inquiry are given in the appended tables. Glasses XXI. to XXIV. were first examined, and the results obtained from these and from the experiments conducted in 1884 point to the conclusion that a glass which approaches in composition to a definite chemical compound has a high resistance. Owing to the very varied compositions of the glasses, the influence of a particular constituent could not be ascertained definitely. Glasses XXV. to XXXII. were therefore made to enable this to be done, and information was also sought as to whether the resistance or specific inductive capacity of the glass was affected by annealing or varied with time. The effect of substituting soda for potash is seen greatly to decrease the resistance of the glass. It was also found that the presence of a considerable amount of potash with lead is consistent with a high specific resistance. Annealed glass is a much better insulator than that which is not annealed. In spite of the disintegration of the surface of some of the glasses, the resistance, measured three times at intervals of six months, was found to be constant. It was at first thought that there might be some connection between the electrical resistance of a glass and the residual twist of fibres made from it, but experiments failed to show that these properties are in any way related.

Electrical Properties.

No. of glass.	Description.	Density.	Specific resistance in ohms.		Capacity	
			Temp.	Resistance $\times 10^{10}$.	Temp.	S.I.C.
XXI.	Lead-potash ...	3.495		Too high to measure. Certainly above 18,000 at 130°.	15°	7.966
XXII.	Lead-potash ...	3.591		Too high to measure. Above 35,000 at 135°.	120°	7.630
					14°	7.991
XXIII.	Barium glass ...	3.565		Too high to measure. Above 59,000 at 140°.	All temps.	8.5
XXIV.	Zinc-soda	3.493	43° 140°	596.5 0.200	15°	7.54
					Conduction very great at high temperatures.	
XXV.	Lime-glass	2.487	149° 116 93 72 55	0.202 1.874 11.901 89.15 531.05	11° 129	6.26 6.79
XXVI.	Lead glass containing potash and soda.	2.99	150 140 130 101 88 66	1.535 18.64 33.59 442.70 1956.50 18034.0	10 130	7.06 7.90
XXVII.	Lead-soda	3.552	142 116 90	136.5 797.3 5249.0	8 130	5.42 5.69
XXVIII.	Barium-potash	3.11	138 125 95 77	6.47 16.01 178.05 1115.50	22 147	6.93 7.18
XXIX.	Lead-potash (annealed).	3.41		Too high to measure. Above 29,000 at 140°.	18 140	7.22 7.42
XXX.	Lead-potash (unannealed).	3.34	142	1328.6	18	6.76
XXXI.	Lead-soda (annealed).	3.408	141 122 102 84	4.874 20.497 102.820 515.94	140 20 140	7.05 8.013 8.302
XXXII.	Lead-soda (unannealed).	3.36	140 120 104 83 73	1.691 4.927 20.821 144.640 215.130	19 130	7.36 8.44

Percentage Chemical Composition.

No. of glass.	SiO ₂ .	PbO.	Fe ₂ O ₃ and Al ₂ O ₃ .	As ₂ O ₃ .	CuO.	BaO.	K ₂ O.	Na ₂ O.	MnO.	B ₂ O ₃ .	ZnO.	MgO.
XXI.	50.5	42.14	0.41	—	—	—	6.93	trace	—	—	—	—
XXII.	44.5	46.6	trace	0.4	—	—	8.0	0.5	trace	—	—	—
XXIII.	33.0	—	6.0*	—	—	48.0	trace	trace	1.0	12.0	—	—
XXIV.	67.6	—	trace	—	—	—	—	10.0	0.4	8.0	9.0	5.0
XXV.	69.04	trace	2.73	—	7.59	—	19.23 †	—	1.31	—	—	—
XXVI.	58.82	26.10	0.43	—	trace	—	6.42	7.35	0.81	—	—	—
XXVII.	40.75	45.19	0.29	—	—	—	—	13.76	—	—	—	—
XXVIII.	52.28	—	0.25	—	—	26.09	19.74	0.64	—	—	—	—
XXIX.	48.25	40.80	0.29	—	—	—	10.65	—	—	—	—	—
XXX.	50.11	39.74	0.12	—	—	—	10.03	—	—	—	—	—
XXXI.	50.42	40.24	0.38	—	—	—	trace	8.77	—	—	—	—
XXXII.	51.46	38.94	0.25	—	—	—	—	9.13	—	—	—	—

* Alumina.

† K₂O and Na₂O combined.

240. The Electrical Conductivity of Glass. R. AMBRONN (*Phys. Zeitsch.*, 1913, 14, 112; 1918, 19, 401).—The electrical resistances of twelve lime-soda-silicate glasses were measured at several different temperatures. It had been shown by Warburg that the conductivity of glass is of an electrolytic nature, and it was found that when a direct current was used the glass became polarised. In the author's experiments, therefore, the current was made alternating and electrodes of burnt-in platinum were used. The method and apparatus are described in the first paper.

The dependence of the electrical conductivity of the glasses on the composition and on the temperature was investigated. It was found that the results could be represented by a relation of the form $L = L_0 e^{-\beta/\theta}$, where L is the conductivity, θ the absolute temperature, and L_0 and β constants, the former being capable of expression as a linear function of the percentages of soda and lime in the glass. Consideration of the values of L_0 derived from the experimental results indicates that not all the sodium and calcium silicate is dissociated, there being no conduction of electricity until out of 100 atoms of substance 11 are atoms of Ca and Na. The bivalent calcium atom and the monovalent sodium atom count equally in producing this minimum number. J. R. C.

241. The Influence of an Electric Field on the Elasticity of Glass. G. ERCOLINI (*Nuovo Cimento*, 1902, 4, 270).—In continuation of a research on the deformation of condensers, the author investigated the influence of an electric field on the elasticity of glass. The glass was successively subject to a tension, a compression, and a shearing force, but in none of these cases was an appreciable variation in the elastic constants to be discerned. J. R. C.

242. The Variation of the Dielectric Constant of Glass with the Pressure. A. WÜLLNER and M. WIEN (*Ann. Physik*, 1903, 11, 618).—In a previous paper the authors showed that the increase in internal volume of spherical and cylindrical condensers produced by electrostriction is smaller than would be expected from the acoustically and mechanically obtained values of the modulus of elasticity (see this vol., Abs. No. 150). Consideration of the results given in that paper lead to the conclusion that the dielectric constant is dependent on the pressure. This is in accordance with the theoretical views of electrostriction, and in the present communication the authors give an account of experiments conducted to determine by direct measurement in what manner it is dependent. It was found that the variation of the dielectric constant produced by pressure perpendicular to the electrical lines of force is, in general, negative. In the case of Thuringian glass it is very small, being somewhat greater with the Jena glass 477^{III} and greatest with flint glass. The sign and magnitude of the variations are such as would be expected from the electrostriction experiments, and the peculiar behaviour of the

glass in these experiments can be explained by a change in the dielectric constant with pressure.

J. R. C.

243. The Resistance of Glass to Fracture. PRINCE B. GALITZIN (*Acad. Sci. St. Petersburg, Bull.*, 1902, 16, 1. Abstracted from *J. de Physique*, 1902, 1, 652).—The author tested tubes of hard Jena and Thuringian glass of various internal and external radii. Each tube was cut into a number of pieces of lengths varying from 20 to 40 cm. Their radii were measured, and they were fastened, in a vertical position, to a metal plate by means of marine glue. Water was compressed inside them and the pressure raised until they broke. The mean internal tension at the time of fracture was thus obtained. It was found (1) to be independent of the rapidity of compression of the water; (2) to vary with the ratio of the internal and external radii; (3) to increase at first with the radius to a maximum value, and then to decrease slowly; (4) to be independent of the absolute thickness of the walls, although the thicker the glass the more likely it is to contain flaws.

J. R. C.

244. Neumann's Method of Determining the Thermal Conductivity of Badly Conducting Bodies. H. HERCHT (*Ann. Physik*, 1904, 14, 1008).—The method is applicable to solids made into spheres or cubes, and was employed by the author to ascertain the conductivity of glass and other substances. The method is fully explained and discussed. The conductivity of the glass specimen, which was examined as a cube, and the composition of which is not stated, was found to be 0.0025.

J. R. C.

245. Double Refraction in Glass Plates with Statical Bending. W. KÖNIG (*Ann. Physik*, 1903, 11, 842).—In a previous paper it is shown that there are two causes producing double refraction in a transversally vibrating glass plate. The first is due to the curvature of the plate and the second to the shearing force. In the present communication the author demonstrates that this is also the case when the plate is uniformly bent. The problem is theoretically considered, and it is shown that the observed optical behaviour agrees with theory.

J. R. C.

246. The Ternary System, $MgO-Al_2O_3-SiO_2$. G. A. RANKIN and H. E. MERWIN (*Amer. J. Sci.*, 1918, [iv], 45, 301).—In addition to the components MgO , Al_2O_3 , SiO_2 , four binary compounds and one ternary compound enter into the system. The binary compounds are $2MgO, SiO_2$ (*forsterite*), MgO, SiO_2 (*clinocristatite*), MgO, Al_2O_3 (*spinel*), and Al_2O_3, SiO_2 (*sillimanite*), whilst the ternary compound is $2MgO, 2Al_2O_3, 5SiO_2$ (regarded as a member of the *cordierite* minerals).

The melting points of the various mixtures of these oxides vary considerably, from 1350° to 1900° , calling for the use of a platinum furnace for the lower melting-point mixtures or an iridium one

for those more refractory. The procedure was to prepare a number of charges thoroughly fused. Mixtures rich in silica were prepared by finely grinding the first melt and remelting until the refractive index of the glass was constant. The primary crystalline substances present were determined by heating a charge at various constant temperatures, followed by rapid cooling (quenching) when the primary crystalline body had become well established.

The following melting points are recorded (corresponding with quintuple points):—MgO 20.3, Al₂O₃ 18.3, SiO₂ 61.4, 1345 ± 5° (eutectic for MgO.SiO₂, SiO₂, and the ternary compound); MgO 10.0, Al₂O₃ 23.5, SiO₂ 66.5, 1425 ± 5° (quintuple point for SiO₂, ternary compound, and Al₂O₃.SiO₂); MgO 16.1, Al₂O₃ 34.8, SiO₂ 49.1, 1460 ± 5° (quintuple point for ternary compound, Al₂O₃.SiO₂, and *spinel*); MgO 25.7, Al₂O₃ 22.8, SiO₂ 51.5, 1370 ± 5° (quintuple point for *spinel*, 2MgO.SiO₂, and ternary compound); MgO 25.0, Al₂O₃ 21.0, SiO₂ 54.0, 1360 ± 5° (quintuple point for 2MgO.SiO₂, MgO.SiO₂, and ternary compound); MgO 56.0, Al₂O₃ 16.0, SiO₂ 28.0, 1700 ± 25° (eutectic point for 2MgO.SiO₂, MgO, and *spinel*); MgO 15.2, Al₂O₃ 42.0, SiO₂ 42.8, 1575 ± 5° (quintuple point for Al₂O₃, *spinel*, and Al₂O₃.SiO₂).

The ternary compound, 2MgO.2Al₂O₃.5SiO₂, is unstable at its melting point, and is considerably affected by solid solution. It occurs in two forms, the μ -form (unstable), which crystallises from glass below about 950° and is transformed into the stable α -form at somewhat higher temperatures. The properties of both forms, especially the α -, resemble the mineral *cordierite*. W. E. S. T.

III.—Lampworked and General Scientific Apparatus

247. **A Still for the Continuous Preparation in Quantity of Water of High Purity.** H. W. MOSELEY and R. G. MYERS (*J. Amer. Chem. Soc.*, 1918, 40, 1409).—Two 5-litre bulbs of high-resistance glass are set at an angle of about 60°. The first is fitted with a pressure tube, distilled water supply, and delivery tubes; the second with an inlet tube and an exit tube about 2 cm. diameter and 20 cm. long. The upper end of this exit tube is blown in such a way as to form a trap, which reduces the possibility of impurities being carried over into the condenser. This tube then connects through a ground joint with an adapter of the Findlay type, the arm of which extends upwards and then passes directly downwards to a block-tin worm condenser.

In the first bulb a 10 per cent. potassium dichromate solution in 5 per cent. sulphuric acid is used, and in the second a saturated

solution of barium hydroxide. Portland cement stoppers are moulded to fit the flasks, and made to fit tightly by means of asbestos cord. Rubber and cork parts are thus entirely eliminated from the apparatus. S. E.

248. An Automatic Mercury Air Pump. A. STOCK (*Zeitsch. Elektrochem.*, 1917, **23**, 35; *Zeitsch. Instrumentenkunde*, 1918, **9**, 150).—Mercury pumps built on the Töpler principle have the advantage that the gas pumped out can be collected for further investigation, but against this stand the disadvantages that the raising and lowering of the mercury require continual attention, and that the mercury continually streaming through the rubber tube slowly becomes contaminated.

In the author's new model the mercury is raised by air pressure, and the pump will work perfectly automatically all day long. The principle of the Töpler is retained. To the body of the pump, *A* (Fig. 19), is sealed the rising tube, *B*, the branch tube, *c*, and the overflow tube, *D*. The safety tube, *E*, rises to a height of about 1 metre, and the drainage vessel, *T*, is provided in case any mercury does pass over the top of *E*. The vessel to be evacuated is attached to the tube leading from the ground junction, *S*₂. The capillary tube, *D*, ends in a thick-walled basin, *P*, from which there are two overflow tubes, *r* returning mercury to the pump and *R* running off any further excess into the vessel *G*. The tube *B* is fitted into the middle neck of the heavy-walled bottle, *F*, and passes down to the bottom of it. Through the tube *d* communication is made to a source of compressed air (about 1½ atmospheres). When this pressure is allowed to act, the mercury rises in the tube *B*, and the long tube *f* acts as a safety tube. If the pressure in the bottle *F* is reduced to atmospheric, then the mercury falls again. The valve *Q* prevents mercury rising up the tube and passing through *r* into the dish, but allows it to flow from the dish into the bottle. To make the pump perfectly safe and automatic, the floating valve, *V*, is necessary. The pressure is applied through *d*, and the mercury rises into the body of the pump and flows over into the dish *P* until the level of the mercury in *F* has fallen and brought down with it the float *V* far enough to allow the air to escape through a small hole at the top of the tube to which *d* is connected. The escape of the air allows the mercury to fall in *A*, and, closing up the floating valve, causes the series of operations to begin again.

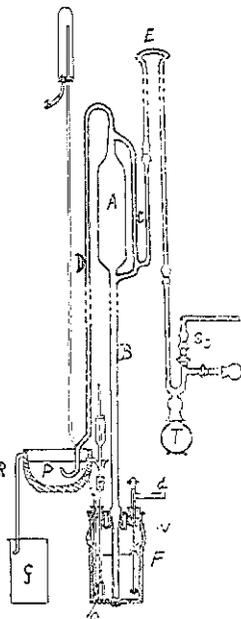


FIG. 19.

S. E.

249. **Glass Chemical Ware, Measuring Cylinders.** A. MOND (Eng. Pat. 119297, 3/10/17).—Graduated measuring cylinders, instead of being blown and made in one piece in the usual way, are made from a tube of uniform bore with a ground-in stopper or plug, acting also as a foot. The foot being movable facilitates the cleaning of the cylinder. It is claimed that the cost of grinding in the foot is compensated by the reduced cost of graduation.



FIG. 20.

S. E.

250. **A Fractional Distillation Tube.** W. G. FRIEDEMANN (*J. Amer. Chem. Soc.*, 1918, 40, 1411).—A fractional distillation tube can be made by fastening together Kjeldahl bulbs by means of rubber tubing, as shown in Fig. 20. A bent glass tube may be substituted for the fractional distillation tube fitted to the uppermost bulb.

S. E.

251. **Methods of Analysis used in the Coal Tar Industry. Tar-acid Separatory Funnels.** J. M. WEISS (*J. Ind. Eng. Chem.*, 1918, 10, 911).—The oil under test is distilled until 95 per cent. has passed over or until the temperature of the vapour reaches 400°. The entire distillate is transferred to a tar acid separatory funnel (Fig. 21), which is designed for oils which have 25 per cent. or more of tar acids. For oils containing less than 25 per cent. of tar acids, a modified funnel (Fig. 22) should be used. After determination of the volume of the oil at 60°, it is extracted with successive portions of 10 per cent. caustic soda until no further contraction occurs. The soda layer is drawn off, and the volume of the remaining oil noted, the reduction in volume being considered as the volume of the tar acids.



FIG. 21.

The first type of tar acid funnel is a tube of about $1\frac{1}{4}$ inches diameter and 16 or 17 inches long, fitted with a ground-in stopper at the top and an ordinary stopcock at the bottom. It is graduated in c.c. from 0 to 100, beginning at the stopcock. Type 2 funnel has two bulbs connected by a $\frac{1}{4}$ -inch tube. The lower bulb holds exactly 65 c.c. and the upper bulb is slightly larger. The $\frac{1}{4}$ -inch connecting tube is calibrated to read from 65 to 100 c.c.

S. E.



FIG. 22.

252. Note on a New Form of Vacuum Stopcock. S. R. MILNER (*Phil. Mag.*, 1903, 6, 78).

—An obvious defect of the ordinary form of mercury sealed stopcock is that, although the interior of the apparatus to which it is connected is sealed off by mercury from the atmosphere, there is no mercury seal between the two portions of the apparatus joined by the stopcock. By employing a hollow key partly filled with mercury, a perfectly air-tight seal can be interposed to prevent the entrance of air into the apparatus by every route along which leakage may occur. As shown in Fig. 23, the tubes *A* and *B* are in communication, but when the key is turned through 180° the separate portions of mercury, m_1 , m_2 , and m_3 , seal off *B* both from *A* and from the atmosphere.

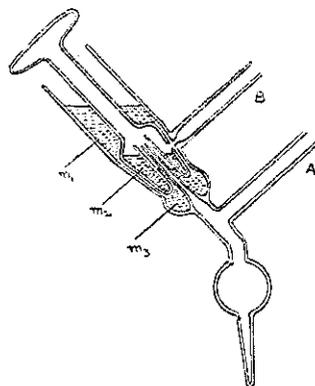


FIG. 23.

The stopcock should be ground fairly conical in shape so as to prevent the key sticking in the barrel, due to the excess of pressure on the outside. It may be noted that there is a true mercury sealing only in the direction from *A* to *B*, so that the apparatus into which it is desired to prevent leakage should be connected to this latter tube.

S. E.

253. A Simple Boiling Point Apparatus for Testing Mercury Thermometers at Temperatures above 100° .

G. DIMMER (*Zeitsch. Instrumentenkunde*, 1918, 38, 33).—Between 0° and 100° well-stirred water-baths are practically always used for testing the accuracy of thermometers, and are found to be very satisfactory, but for temperatures above 100° oil-baths, even when well stirred and electrically heated, are not found to be nearly so satisfactory. At still higher temperatures, a saltpetre-bath may be used, but here again it is difficult to get steady temperatures, so that it appears advantageous for temperatures between 0° and 450° to work with fixed points.

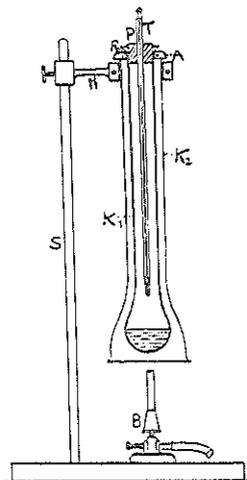


FIG. 24.

A boiling-point apparatus for use at these higher temperatures may be arranged as follows. An iron stand, *S* (Fig. 24), carries in a movable holder, *H*, an open glass jacket, *K*₂. The inner glass flask, *K*₁, having a total length of 480 mm., is supported in a split ring, *R*. The cork,

P, carries the thermometer, and also has a small hole to allow of the release of pressure from the inside. The vapour of the boiling liquid rises above the end of the mercury thread, and boiling is kept up until a steady temperature is attained. From tables giving the relation between the boiling points of the substances used and the barometric pressure, the true boiling point is calculated, and the correction to apply to the thermometer reading is deduced.



Fig. 25.

For the higher temperatures, it is necessary to have a shield over the bulb of the thermometer and over any subsidiary bulbs (Fig. 25), in order to carry off any cool liquid which has been condensed higher up the apparatus and has run down the stem of the thermometer. At lower temperatures, the use of such shields is not essential, though it is recommended that they be used in all cases.

The temperatures suggested as suitable for use as fixed points are the boiling points of aniline (184.1°), naphthalene (218°), benzophenone (306°), and sulphur (444.6°). S. E.

254. Note on Jets for Burettes. J. H. COSTE (*Analyst*, 1917, 42, 385).—To be satisfactory for delicate work with small quantities, a burette jet should deliver a sufficiently rapid stream, and, when the rate of flow is checked, allow the solution to fall in a succession of small drops. The size of the drop should be commensurate with the accuracy of the burette.

The usual form of burette jet is made of thick-walled glass, say about 3 mm. external and 1 mm. internal diameter. Such jets deliver drops of about 0.05 c.c., and are insufficiently sensitive for the best use of a 50 c.c. burette of the accuracy of the National Physical Laboratory standards if less than 25 c.c. are needed for a titration. Tap burettes frequently contain an inconvenient and undesigned air trap under the barrel of the tap. The influence of the jet on the size of the drop is determined by its external cross-section, and drawing out the jet in the flame, therefore, does very little good, as its principal effect is to reduce the rate of delivery.

The author made a series of jets and carried out measurements with them. He arrived at the conclusion that the size of the drop may best be reduced by having a fine, thin-walled jet with a fairly long cylindrical capillary. J. D. C.

255. Increasing the Delicacy of Delivery of Burettes. E. H. MERRITT (*Analyst*, 1918, 43, 138).—The author recommends waxing both the inside and the outside of the jet, as follows. The clean and dry burette is warmed, and the jet immersed to a depth of about three-quarters of an inch in melted paraffin wax (m. p. about 55°). The burette is then vigorously shaken for a few seconds to remove excess of wax. If the layer of wax is too thick, it can be reduced by warming gently over a small flame

and shaking. By this means it is quite easy to increase the delivery of a 50 c.c. burette from 20 to 40 drops per c.c.

After waxing the jet in this manner, each drop leaves cleanly and the liquid has no tendency to creep up the outside. Increased delicacy is obtained without weakening the jet by making the walls thinner.

J. D. C.

256. The Metallography of Tungsten. ZAY JEFFRIES (*Engineering*, 1918, 106, 239).—When metal tungsten consists of equiaxial or recrystallised grains, it is very brittle at the ordinary temperature, but when it has a fibrous structure it may be ductile, which is just the reverse of the phenomena exhibited by ordinary metals. At 3200°, approximately 150° below its melting point, the equilibrium grain size is reached in a few minutes, whilst at 2600° the rate of growth of the grains is only about one-tenth as fast as it is at 3200°.

When drawn into wire, a fibrous structure is developed, and with the improved ductility the tensile strength is also increased. The finer the wire, the greater is its tensile strength per square inch. For use in lamps, thoria is always added to tungsten, to control the direction and to a certain extent the degree of grain growth in such a manner as to render the filaments rugged and free from "off-setting." Generally 2 per cent. of thoria is added. If more than this is used, it is difficult to work the tungsten into very small wires.

For lamp filaments, it is considered desirable to keep the grains in the ingots fairly small (for example, 6,000 per sq. mm.). They should not, however, be too small, as the material then becomes extremely hard to work, especially in the smaller sizes.

Tungsten lamps are so designed that when used at the rated voltages the temperature of the filament is above the recrystallising temperature of the metal, but even when this is done the grains become very much elongated during the life of a lamp. If the filament develops coarse grains, it becomes much stiffer at high temperatures, thus preventing sagging due to its own weight. There is a danger, however, in producing coarse-grained structures, for if a boundary line between two crystals cuts sharply across a section of the filament, displacement perpendicular to the axis may occur, thus causing the phenomenon known as "off-setting."

S. E.

IV.—Decorated Glass.

257. Notes on the "Sang de Bœuf" and the Copper-red Chinese Glazes. J. N. COLLIE (*Trans. Cer. Soc.*, 1918, 17, 379).—The author here gives some account of the red or reduced copper glaze.

In the green copper glaze, the copper is present in the form of a cupric or fully oxidised copper compound; in the red glaze, it is present in the reduced state, either as a cuprous salt or as metallic copper in the colloidal state diffused through the glaze.

That the copper is in a colloidal state receives a certain amount of support from the fact that the slightest overheating in the furnace destroys the colour, first rendering it dull brown or opaque, and then the colour almost entirely disappears. The author states that the red glaze was first mentioned in Chinese writings, 1426–35, and he proceeds to give a history, together with distinguishing characters, of the ware. From its appearance, the glaze was described as "sang de bœuf."

The amount of copper in the glaze is very small, and if the latter is fused in an oxidising flame it becomes very pale bluish-green in colour and full of bubbles.

If a section running through the paste and the glaze be examined under the microscope, only a thin line of red is seen.

Iron is present in the "sang de bœuf" glaze; it is quite possible that a ferrous salt would reduce the copper and bring out the red colour. Analysis shows it to be a felspathic glaze containing silica, alumina, lime, and alkalis.

Another red, as brilliant as the best "sang de bœuf," but opaque, has also been used by the Chinese. It is a lead glaze, and apparently is far older than the "sang de bœuf."

The earliest example known to the author is a Roman Egyptian glass. When broken, it is vitreous and like the best red sealing-wax. The author is indebted to Sir Herbert Jackson for the following partial analysis:—

Roman Egyptian Glass.

SiO ₂	38.20 per cent.	CaO	8.15 per cent.
PbO	31.10	K ₂ O	0.61
CuO.....	4.67	Na ₂ O	10.29
Al ₂ O ₃ and Fe ₂ O ₃ ...	2.10	SnO ₂	0.70
MnO	0.10		

The Chinese probably discovered the glaze for themselves at a later date.

A. M. J.

258. Varnish for Backing Silvered Mirrors. (*Spechsaal*, 1901, 34, 1398).—As the silver film is so delicate, the varnish used for protecting it must be free from acids and must contain little

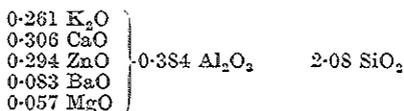
or no chlorine or sulphur compounds. Pure shellac is recommended. The first layer must be applied as a very thin liquid in order not to injure the film. The solution suggested is composed of 4 kg. of shellac, 20 litres of spirit, and 1/20th litre of spirit of sal-ammoniac. After applying this two or three times, a covering paint is put on consisting of the above solution together with 5 kg. of "English red," 1 kg. of "Krewser white," and 1 kg. of Venetian turpentine. The last, being a very viscous liquid, should be first dissolved in the spirit. The quantity of turpentine needed is variable; the correct amount is used when a coat dries with a bright lustre. If the coat presents a matt appearance, more turpentine should be added. The varnish should be applied to warmed glass with a camel's hair brush.

J. R. C.

259. A Cobalt-Uranium Green Glaze for Terracotta.

HEWITT WILSON (*J. Amer. Cer. Soc.*, 1918, 1, 238).—Previous methods of producing chromium, nickel, iron, and uranium compounds have depended on the use of copper.

The procedure of the author was to use a dull matt glaze as base, uranium oxide and a cobalt stain being added in varying amounts. The formula of the glaze was as follows:—



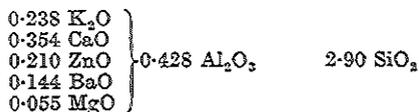
It matured at from cone 3 to 7 in a commercial kiln. The blue stain added to the glaze had the following composition:—

Cobalt oxide	16.0 per cent. (raw)
English ball clay	53.0 " "
Zinc oxide	31.0 " "

Cobalt stain and uranium oxide were added to the matt glaze. Each glaze was sprayed upon a terra-cotta tile to which a coating of white underslip had been first applied. The glazed tiles were placed in a commercial terra-cotta muffle kiln and burned to between cones 6 and 7 for a period of seventy hours, and then passed through a cooling period of eighty hours.

From this series it was found that 3 per cent. of stain produced a yellowish-brown colour, changing to green as the uranium content increased. With 7 per cent. of uranium oxide, the glaze, although green, had a decided yellow cast.

Using a bright glaze of the following formula as a base, another series was prepared by the addition of uranium oxide and cobalt stain in the same proportions as were used for the previous series.



This glaze matures at from cones 4 to 7 when fired either in a small or large kiln.

The colours developed were in general the same as those of the above series, although they were not so distinct. The addition of uranium oxide alone tended to produce fine dark specks.

Although it is not claimed that uranium-cobalt greens will replace the chromium greens, they have a place in terra-cotta work in which uranium shades are desired and the complexities of chromium troubles are to be avoided.

C. M. M.

V.—Optics and Optical Instruments.

260. The Correction of Telescope Objectives. T. SMITH (*Phil. Mag.*, 1918, 36, 405).—It is considered that the formulæ for this purpose derived by Allen (this vol., A., 164) are open to criticism. The evaluation of the correction involves a large amount of arithmetical work. Many of the author's coefficients are related, and he uses these relations for the simplification of some of the expressions. He also discusses the trustworthiness of the results of Allen's calculations.

J. R. C.

261. Nomenclature of Optical Glass. W. ZSCHOKKE (*Zeitsch. Instrumentenkunde*, 1918, 38, 49).—This is a communication from the Sendlinger Optical Works, which were started shortly before the outbreak of war. The origins of the terms "flint" and "crown" glass are explained. A comparison diagram of the relation between density and refractive index for old French glasses and new Jena glasses is given. In the former case, the refractive index increases nearly uniformly with the density; in the latter, the increase is not so great.

When the Sendlinger Works were first started, the question of nomenclature of optical glass was considered. Heavy barium crown glass of high refractive index and relative dispersion is completely outside the ordinary crown series, whilst baryta flint, with a much smaller dispersion for the same refractive index for the D-line, is equally outside the ordinary flint series. Glasses of these two types are therefore named "Barion" and "Barint," respectively, and are so shown in the works catalogue. Further, the type of any glass is indicated by the first three decimals of μ_D (the refractive index for the D-line), and ten times the relative dispersion $v = \mu_D - 1/\mu_C - \mu_G$. For example, a borosilicate crown of $\mu_D = 1.516$ and $v = 64.0$ is "Kron 516/640."

A list of the thirty-five glasses so far made in this factory, with their optical constants, and the most nearly corresponding glass in the Jena catalogue, is appended

Type of glass.	μ_D	ν	$\mu_F - \mu_C$	$\mu_D - \mu_C$	$\mu_F - \mu_D$	$\mu_F - \mu_D$	Corresponding Jena glass.
Kron 507/628	1.5072	62.8	0.00808	0.00241	0.00567	0.00453	0599
510/634	1.5100	63.4	0.00805	0.00240	0.00565	0.00451	0144
511/638	1.5114	63.8	0.00802	0.00239	0.00563	0.00448	
511/643	1.5110	64.3	0.00795	0.00236	0.00559	0.00443	
512/603	1.5117	60.3	0.00848	0.00251	0.00597	0.00480	06223
516/640	1.5160	64.0	0.00806	0.00241	0.00565	0.00448	03832
519/604	1.5190	60.4	0.00859	0.00254	0.00605	0.00486	03453
533/602	1.5330	60.2	0.00886	0.00261	0.00625	0.00503	
Barion 540/599	1.5398	59.9	0.00901	0.00266	0.00635	0.00511	0227
563/581	1.5632	58.1	0.00968	0.00285	0.00683	0.00552	
573/575	1.5731	57.5	0.00996	0.00293	0.00703	0.00568	0221
590/611	1.5900	61.1	0.00965	0.00286	0.00679	0.00544	02122
601/573	1.6000	57.3	0.01048	0.00309	0.00739	0.00596	
609/589	1.6091	58.9	0.01035	0.00305	0.00730	0.00588	02071
611/558	1.6109	55.8	0.01094	0.00321	0.00773	0.00626	03961
614/564	1.6137	56.4	0.01088	0.00320	0.00768	0.00623	02994
615/567	1.6146	56.7	0.01084	0.00319	0.00765	0.00619	

Type of glass.	μ_D .	ν .	$\mu_Y - \mu_C$.	$\mu_U - \mu_C$.	$\mu_Y - \mu_U$.	$\mu_U - \mu_Y$.	Corresponding Jena glass.	
Barint	548/532	1.5480	53.2	0.01030	0.00302	0.00728	0.00595	
	570/560	1.5704	56.0	0.01018	0.00300	0.00718	0.00583	
	580/538	1.5799	53.8	0.01079	0.00316	0.00763	0.00622	
	626/393	1.6259	39.3	0.01591	0.00456	0.01135	0.00960	
	667/363	1.6752	36.3	0.01813	0.00515	0.01298	0.01106	
Flint	523/513	1.5232	51.3	0.01020	0.00300	0.00720	0.00586	
	541/477	1.5409	47.7	0.01134	0.00329	0.00805	0.00666	
	549/461	1.5494	46.1	0.01193	0.00347	0.00846	0.00705	
	569/426	1.5693	42.6	0.01338	0.00386	0.00952	0.00801	
	571/430	1.5711	43.0	0.01327	0.00382	0.00945	0.00792	
	577/414	1.5770	41.4	0.01393	0.00400	0.00993	0.00833	
	605/390	1.6049	39.0	0.01553	0.00445	0.01108	0.00935	
	613/369	1.6133	36.9	0.01663	0.00474	0.01189	0.01010	
	617/365	1.6170	36.5	0.01689	0.00482	0.01207	0.01028	
	619/377	1.6193	37.7	0.01644	0.00470	0.01174	0.00998	
	620/362	1.6204	36.2	0.01714	0.00488	0.01226	0.01044	
	624/357	1.6242	35.7	0.01749	0.00498	0.01251	0.01070	
	649/338	1.6480	33.8	0.01920	0.00547	0.01373	0.01181	
								07550
								0722
							0748	
							03289	
							Telescope flint	
							0378	
							0376	
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							0167	
							0103	
							093	
							0102	

262. Reflecting Prisms. T. Y. BAKER (*Trans. Optical Soc.*, 1918, 19, 113).—In many optical instruments it is preferable, in the author's opinion, to use a prism as a reflector in place of a mirror. The author discusses the geometry of the ray-paths of various types of single, double, and triple reflection prisms in which the reflections are all in one plane. He mentions instruments in which such prisms are employed and suggests other possible applications. J. R. C.

263. The Detection of "Ghosts" in Prisms. T. SMITH (*Trans. Optical Soc.*, 1918, 19, 120).—The author explains the meaning of the term "ghosts," and points out that they are nearly always due to the occurrence of reflections in ways that are not intended. The method of detection is described by the aid of numerous diagrams. The description cannot be abstracted, and reference should be made to the original paper. Several photographs are given of "ghosts" produced by prisms. J. R. C.

264. The Change in the Optical Behaviour of different Glasses through Elastic Deformation. F. PÖCKELS (*Ann. Physik*, 1903, 11, 651).—The author refers to some criticisms of his method advanced by Filon (previous abstract). He also states that the glass 0428, the composition of which was uncertain in his previous papers (this vol., A., 96, 182), has been definitely ascertained. It is very different from what it was assumed to be, and the value of Young's modulus derived by Winkelmann's formula, using the amended composition, is approximately the same as that found by direct measurement. J. R. C.

265. The Variation with Wave-length of the Double Refraction in Strained Glass. L. H. G. FILON (*Camb. Phil. Soc. Proc.*, 1902, 11, 478; 1903, 12, 55, 313).—In the first paper an account is given of experiments on glass beams, with the object of ascertaining how the double refraction, induced by strain, varies with the wave-length of the light. The experiments exhibited the variation continuously through the spectrum. They showed that, as a rough first approximation, Wertheim's law, that the double refraction exhibits no dispersion, is correct; a divergence was, however, shown to exist, the differences in the refractive indices being smaller in the red than in the violet. The accuracy attainable under the given conditions, however, was not sufficient to allow the law of this divergence to be obtained.

In the second investigation, therefore, a new method of procedure was adopted allowing of greater precision. If r is the relative retardation of the two beams of light produced by a thickness τ of glass, and T the mean stress in the glass, then $r = C\tau T$, C being a constant, which is called the stress-optical coefficient. When this difference of retardation is equal to a multiple of the wave-length, light of that particular wave-length is quenched when the

block of glass is examined between crossed Nicols and $\lambda=C \cdot T$. In the experiments detailed in the second paper, ordinary plate-glass of unknown composition was examined, and the results showed a steady decrease of the stress-optical coefficient from $\lambda 4500$ to $\lambda 6500$, namely, from 26.6 to 25.0.

The glasses employed in the experiments described in the third paper were a series of flint glasses from Jena, the approximate molecular compositions of which are given. In the majority of cases, a steady decrease of C with increasing wave-length was obtained, but with one glass a parabolic increase was found. This glass was S57, a lead silicate with 79 per cent. of lead. It was one of those examined by Pockels (this vol., Abs., Nos. 96 and 182), who obtained a similar result. His values of C were nearly twice as great as those obtained by the author, both being small, and it is suggested that the glasses were of slightly different composition.

In general, the experiments confirm Pockels' results. They indicate that the difference of the refractive indices is greater in the violet than in the red for those glasses which are not borates; that, as the percentage of lead increases, the variation in the difference decreases; it is probably zero for a glass containing about 66 per cent. of PbO. After this the variation alters in sign, and its value begins to increase rapidly. J. R. C.

266. The Balsam Problem. J. W. FRENCH (*Trans. Optical Soc.*, 1918, 19, 143).—As an introduction to the discussion of this problem, the author sets out the methods by which the components of an optical system may be assembled. Of these, the one most interesting to the glass technologist is the Parker and Halliday method of actually joining the two surfaces. There is reason to believe that the polished surface layer of glass softens at a temperature at least 100° below the softening point of unmodified glass. If, therefore, the parts of the combination are held in optical contact and heated to a temperature considerably below the softening point of the body of the glass, the surface layers which are in optical contact may be welded together. That such welding takes place is evident, for the surfaces so joined cannot be separated again.

The remainder of the paper is devoted to the consideration of the origin of the use of Canada balsam, its behaviour when baked for varying periods, and possible substitutes for it. J. R. C.

267. An Improved Form of König's Spectrophotometer. F. F. MARTENS and F. GRÜNEBAUM (*Ann. Physik*, 1903, 12, 984).—In the new arrangement, the two beams of light, after passing through adjacent slits, are collimated and fall on a flint-glass prism. They then pass through a Wollaston calcite prism and through a biprism, being brought to a focus by a telescope lens. By means of a Nicol prism, the intensities of the four images thus produced can be equalised and the light from the two sources compared.

J. R. C.

268. Note on a Telescopic Focussing Apparatus for Photomicrography. A. F. HALLIMOND (*J. Iron Steel Inst.*, 1918, *Engineering*, 1918, 106, 448).—In the ordinary vertical camera used for micrographic work, the height of the focussing screen is often a source of inconvenience, especially in the case when the camera is suspended to avoid vibrations. The apparatus now described is designed to overcome this difficulty in a manner similar to that ordinarily used in reflex cameras.

The rays proceeding to the microscope eyepiece, which would normally converge to a focus on the photographic plate, are reflected horizontally by a movable plane mirror. The reflected beam is focussed by movement of the telescope objective, and the image so given is examined by an eye lens. The exposure is made by turning the mirror from its inclined position to the vertical, thus allowing the light to pass straight through on to the sensitive plate, the dark slide having been opened previously. S. E.

269. Report of the Committee on Standards for Spectacles and Spectacle-making. O. HENKER (*Deut. Mech. Zeitung*, 1917, 131).—The committee set up by the German Optical Society decided to adopt, with a few variations, the American standards. In the following table the two systems of classification are compared.

1. BEVEL-EDGED.

(a) Round.

Designation	{ German	0101	0105	0111	0115	0120	0126
	{ American						
	{ (round) ...	1	0	00	000	000½	0000
Diameter	{ German	32-15 ^{mm}	33-42	35-33	36-61	38-20	40-11
in mm.	{ American ...	32-4 ^{mm}	33-7	35-6	36-8	38-3	40-2

(b) Oval.

Designation	{ German	9101	9105	9111	9115	9120
	{ American					
	{ (regular					
	{ oval)	1	0	00	000	000½
Length :	{ German					
Height	{ 36-49 : 27-49, 37-77 : 28-77, 39-69 : 30-69, 40-97 : 31-97, 42-56 : 33-56					
	{ American					
	{ 36-5 : 27-5, 37-8 : 28-8, 39-7 : 30-7, 41 : 32, 42-5 : 33-5					

2. SURFACE-EDGED.

(a) Round.

Designation	{ German	037	038-5	040	041	042-5
	{ American					
	{ (round)	1	0	00	000	000½
Diameter	{ German	37	38-5	40	41	42-5
	{ American	37	38-5	40	41	42-5

(b) *Oval.*

Designation	German	937	938.5	940	941	942.5
	American (regular oval)	1	0	00	000	000½
Length :	German	37 : 28	38.5 : 29.5	40 : 31	41 : 32	42.5 : 33.5
Height	American	37 : 28	38.5 : 29.5	40 : 31	41 : 32	42.5 : 33.5

J. R. C.

VI. Fuels, Refractories, and Furnaces.

270. Gas Producers and Gas Firing. O. HAPPAH (*Ker. Rundschau*, 1918, 26, 17, 89, *et seq.*).—A lengthy article dealing with the principles and practice of producer gas manufacture.

Producers are divided into two main types:—(A) Shaft producers, with flat or step grates; (B) revolving grate producers.

In shaft producers for low-grade fuels and slack, step grates are found to be the most efficient. The percentage composition of the gas obtained from lignite briquettes (containing 13.3 water and 4.6 ash) is given as: nitrogen, 64.2; carbon monoxide, 29; carbon dioxide, 4; hydrogen, 2.5. This gas had a calorific power of 978 calories, and gave a temperature of 1812°. Under actual working conditions, the gas may contain up to 6—12 carbon dioxide and 50.67 nitrogen if the process is inefficiently controlled.

The following figures, taken from the "Engineer's Pocket Book," are given for average producer gas:—Mean "molecular weight," 24.25; density (air=1), 0.84; volume reduction on combustion, 21 per cent.; air required for combustion, 1 cu. m. gas requires 1 cu. m. air; calorific power, 1100—1180 cal.; average percentage composition by volume, hydrogen, 18; carbon monoxide, 24; carbon dioxide, 6; nitrogen, 52.

The value of the gas, in the author's view, depends chiefly upon its carbon monoxide content, and not on the hydrogen content, as is frequently assumed.

Two types of the Siemens producer are described briefly, having as their object (a) preheating the air supplied to the producer (Fichtel's producer), and (b) decomposing the tar and heavy hydrocarbons (Stegmann's producer).

The revolving grate types of producer have made rapid advances during the last twenty-five years. As compared with the older type of shaft producer, they have several advantages, amongst which are the following:—(1) They require less attention; (2) they are much more convenient to handle in several respects, for example, stoking, ash removal, etc.; (3) they can be utilised for the gasification of cheaper grades of fuel; (4) they are easier to control if the supply of gas required is a fluctuating one.

The speed of revolution of the ash basin determines the depth of the ash bed in the producer, and must be arranged to suit the ash content of the fuel. In ordinary working, this speed may be one revolution in three to five hours, which may be increased in forced working and with a fuel with 10—15 per cent. of ash to one revolution per hour. The water in the revolving jacket should not be allowed to attain a temperature of more than 80°.

The most suitable diameter for such producers is 2·6 to 3·0 metres. With inferior fuel or fine slack, the air-steam blast may be introduced at a water-gauge pressure of 400—600 mm. The air necessary for the gasification of coal is 2·5 to 3·0 cu. m. per kilogram of coal, and the average steam required about 0·12 kg. per kilogram of coal, though the steam may be increased to nearly double this amount in special circumstances.

The producer plant should have a capacity of at least 25 per cent. in excess of the estimated requirements, so as to provide a reserve in case of accidents.

The method of lighting up a producer is described, with the necessary precautions to be observed. The gas produced in the initial stages, which is too poor for furnace work, is led to an emergency chimney and there burnt to avoid becoming a nuisance to the neighbouring district, and is only led into the furnace when analysis shows it to be of the required standard.

The most suitable air pressure, steam saturation, depth of ash bed, speed of grate revolution, etc., must be found for each particular fuel by trial, controlled by repeated and systematic analysis of the gas. Occasional tests over a period of four to twelve weeks are advisable to ascertain the efficiency of the producer.

A sketch of a battery of three producers with mechanical arrangements for supplying fuel to the hoppers and dealing with the ashes is given, and includes an installation of the necessary instruments for controlling the temperature and pressure of the air and gas at various points in the system. The installation of a gas regulator to ensure a steady pressure of gas is also recommended.

The author also sets out the following advantages of gas over coal firing: (1) less excess air is required for combustion; (2) the easy regulation of the gas and air supply, with consequent control over the oxidising or reducing conditions in the furnace; (3) very poor grade fuels can be gasified, and the gas used for the attainment of temperatures not possible under direct firing conditions (for example, a producer gas from peat contained 33 per cent. of steam. After passing through a condenser, the gas issuing contained only 2 per cent. of steam, and gave a temperature of 1960° when burnt with ordinary air, and 3160° when gas and air were preheated to 1200°); (4) the producer plant is independent of the furnace itself, and this leads to freedom from dirt and dust and greater cleanliness in the furnace houses; (5) both gas and air can be preheated, and higher temperatures reached.

J. H. D.

271. The Standardisation of Tests for Refractory Materials. (Part I.). Provisional Specification (*Committee of Ceramic Society, Trans. Cer. Soc., 1918, 17, 300*).—It is proposed to standardise the mode of conducting tests so as to eliminate as far as possible variations in results due to peculiarities in the methods of conducting the tests by different workers.

I.

Chemical Analysis of Fireclays, Raw Ganisters, Quartzose Rocks, and Manufactured Products.—A representative sample must be obtained, and the following determinations made:—

(a) *Hygroscopic moisture*, determined by heating 5 grams at 110° until there is no further loss in weight.

(b) *The loss on ignition*, determined by heating 1 gram of the dry clay in a platinum crucible until the weight becomes constant when heated in a blowpipe flame.

(c) *The silica*, determined by mixing intimately the ignited clay with 10—15 grams of sodium carbonate in the platinum crucible. Contents of crucible are brought to a quiet state of fusion, cooled, extracted with water, collected in a porcelain basin, treated with hydrochloric acid, evaporated to dryness on a water-bath, and then heated in an air oven at 110° until dry. The residue is then moistened with hydrochloric acid, further treated with hot water, and filtered. The filtrate is returned to the basin, again evaporated to dryness, and the mass dried as before until free from hydrochloric acid. It is then digested with hydrochloric acid and hot water, and again filtered. The two precipitates are ignited and weighed.

To correct for small quantities of oxides of titanium, phosphorus, aluminium, and iron, 5 c.c. of water, a few drops of concentrated sulphuric acid, and about 15 c.c. of hydrofluoric acid are cautiously added, evaporated to dryness, afterwards ignited, cooled, and weighed.

(d) *The Aluminium, Iron, and Titanium (Ammonia Precipitate).*—Two to three grams of solid ammonium chloride and an excess of ammonia are added to the hot filtrate from the silica, and the solution filtered immediately. After washing two or three times with hot water, the precipitate is redissolved in a slight excess of hydrochloric acid.

The combined filtrates are heated (80—90°), excess of ammonia solution is added, and the liquid filtered. The precipitate is washed with ammonium nitrate solution. The combined filtrates are now evaporated to about 100 c.c., and, whilst still hot, 2—3 c.c. of ammonia added. The liquid is again filtered; the filtrate is reserved for the determination of the lime and magnesia. The three filter-papers are burnt in the platinum crucible containing the silica residue. When the weight is constant, the contents are fused with 5—6 grams of fused potassium bi- or pyro-sulphate. When cold, the cake is dissolved in water containing a little sulphuric acid, made up to 250 c.c.

The ferric and titanic oxides are determined colorimetrically in this solution.

(e) *The Lime*.—The lime is precipitated by means of 1–3 grams of ammonium oxalate. After standing for two hours, the precipitate is redissolved in nitric acid, again reprecipitated, and again allowed to stand. It is then filtered and ignited in a platinum crucible.

(f) *The Magnesia*.—Sodium ammonium phosphate is added to the filtrate from the ammonium oxalate precipitate. The mixture must stand for at least three hours. It is then filtered, the residue redissolved in nitric acid, reprecipitated, and again allowed to stand. The mixture is filtered through a Gooch crucible, ignited, and weighed as magnesium pyrophosphate.

(g) *The Alkalies*.—About 0.5 gram of finely powdered dry clay is intimately mixed with about 0.5 gram of ammonium chloride and 3 grams of calcium carbonate, transferred to a platinum crucible, and heated, at first gently, then at a dull red heat, for about one hour.

The cake is transferred to a porcelain dish, and the crucible thoroughly washed with hot distilled water, digested for thirty minutes, filtered, and the precipitate washed with water eight or nine times. The calcium carbonate in the filtrate is precipitated by means of ammonium carbonate, and, after filtering, the solution is evaporated to dryness in a platinum basin. The dry residue is ignited to faint redness. When cold, 3 c.c. of ammonium carbonate solution are added to the residue to precipitate the last traces of lime, the dish is then covered and allowed to stand overnight. This is then filtered into a platinum dish, evaporated to dryness, and when dry moistened with a small amount of concentrated hydrochloric acid and again evaporated.

The residue is ignited at a dull red heat, cooled, and weighed; this residue is then washed out into a small porcelain dish, and the platinum dish reheated and weighed. The difference in weight represents the alkali chlorides.

The solution containing the alkali chlorides is poured into a small porcelain basin and evaporated almost to dryness with perchloric acid. The residue is washed with absolute alcohol containing perchloric acid, filtered through a Gooch crucible, dried at 120°, and weighed as potassium perchlorate.

(h) *The Sulphur* in firebricks is determined as in dolomite; the determination is only useful in special cases, since a large proportion is often obtained by absorption from flue gases.

II.

Analysis of Dolomite and Magnesite.

The determination of hygroscopic moisture, loss on ignition, alkalies, silica, alumina, lime, magnesia, iron, and titanium is very similar to the determination of these substances in clays, although some special points are observed,

The Determination of Phosphorus and Sulphur.—For a determination of these elements, a separate 1 gram of the sample is fused with sodium carbonate, as for the silica. (A sulphur-free flame is necessary for fusions and evaporations.)

The silica is removed as usual and the filtrate made up to, say, 500 c.c. 250 c.c. are taken for each determination. The portion for sulphur is neutralised with ammonia, then just acidified with strong hydrochloric acid, the solution heated to 90°, and a hot solution of 2—3 grams of barium chloride in 15 c.c. of water is slowly added with constant stirring. The solution is filtered after standing for three or four hours, and the precipitate gently ignited, cooled, and weighed as BaSO_4 . The phosphorus is determined in the other 250 c.c. by first neutralising the solution with ammonia, adding 2 grams of ammonium nitrate and 10 c.c. of strong nitric acid, heating to about 80°, and then adding a solution of 1—2 grams of ammonium molybdate in 15 c.c. of water with constant stirring. The solution is allowed to stand for three or four hours, and is then filtered through a small filter-paper. The precipitate is redissolved in ammonia. 20 c.c. of ammonium nitrate solution and 1 c.c. of ammonium molybdate are then added to the solution, which is then heated until gas bubbles begin to form. 20 c.c. of hot 5 per cent. nitric acid are then added with constant stirring. After standing for three or four hours, the solution is filtered through a Gooch crucible; the precipitate is washed, dried, ignited at 800°, and weighed as $24\text{MoO}_3 \cdot \text{P}_2\text{O}_5$.

III.

The Identification of the Various Forms of Silica in Silica Bricks.

Tridymite and cristobalite are often present in silica bricks without any definite indication of crystalline form; hence it is necessary to determine their refractive indices in order to distinguish them.

The refractive indices are quartz, 1.549; tridymite, 1.477; cristobalite, 1.484. The material must first be powdered to a degree of fineness sufficient to ensure a separation of the component minerals, and then placed in a liquid of known refractive index.

The Becke, or bright-line method, is often employed for the determination, but a still better method is that of Schröder van der Kolk.*

The method consists in viewing on a dark ground fragments of minerals placed in a liquid of approximately their own refractive index and illuminated from below by oblique white light from all sides.

* The method has been described by Schröder van der Kolk in his work, "Kurze Anleitung zur Mikroskopischen Krystallbestimmung," published 1898. A discussion and practical exposition of the method was contributed by Mr. Allan Dick as an appendix to the Kaolin, China Clay, and China Stone Handbook, *Mem. Geol. Survey*, 1914.

If a mineral and a liquid have the same refractive index for yellow light, then the mineral, if viewed under the conditions mentioned above, will have deep ultramarine-coloured fringes.

If the liquid is of higher refractive index, the blue colour is paler and brighter, until with yet higher indices the fringes are composed of white light.

If the liquid is of slightly lower refractive index than the mineral for yellow light, red or orange fringes result, and the colour becomes pale and brighter as the refractive index of the liquid is diminished.

If, therefore, a solution of mercury-potassium iodide in water be made and diluted until its refractive index for sodium light is 1.477 (the mean refractive index of tridymite), the individual grains of this mineral, when viewed as described above, will show the characteristic ultramarine fringes. The same liquid, however, if used for cristobalite, which has a slightly higher refractive index than tridymite, will give with this mineral orange-coloured fringes, while quartz has a refractive index so far removed from that of the liquid that it will be fringed with white light.

IV.

The Porosity, Water Absorption, and Specific Gravity Tests.

The material to be tested for porosity is cut into rough cubes, 2-inch side, dried at 110° for about two hours, and weighed. The cubes are then soaked overnight in water under reduced pressure, then weighed suspended in water. The surface is then wiped and the cube again weighed. The porosity is one hundred times the quotient obtained by dividing the difference between weights of the piece soaked and dried by the apparent loss in weight which the soaked piece suffers when weighed in water. Duplicates should agree within 0.2 per cent. Very dense or close-textured material should be soaked for two or three days.

The specific gravity of the solid material is the quotient obtained by dividing the weight of the dry test-piece by the loss of weight which it suffers when suspended in water after soaking. Unless "water absorption" is specifically required, it is best to use an oil like turpentine, kerosene, or paraffin, since the oil penetrates more rapidly into the pores.

V.

The Shrinkage of Clays on Drying and Firing.

Clay dried at a temperature not exceeding 70° should be crushed to pass a 28 sieve, made up with water to the proper working consistency, and thoroughly pugged or wedged. The clay is moulded in a suitable mould of metal or wood. (The size recommended by the Committee on Standards of the American Ceramic Society, 1918, is satisfactory.)

A portion of the clay from which the briquette is moulded is

weighed on a watch-glass, dried at 110° , and again weighed. The weight of water lost in drying is expressed as a percentage of the final weight of the dry piece.

The test-piece is marked with vertical lines about 9 cm. apart and allowed to dry first at the ordinary temperature, then at $70-80^{\circ}$ for four or five hours, and finally at 110° .

The distance of the marks apart is again measured, and the linear drying shrinkage expressed as a percentage of the length of the test-piece.

The test-pieces are then fired in a suitable muffle or thin-walled saggar in an oxidising atmosphere.

The rate of heating should not exceed five cones (or 100°) per hour until approximately 900° is reached, after which the rate of heating is decreased to about one cone per hour until the end of the operation.

The test-pieces are withdrawn from the kiln at various cones, covered with hot sand, and kept at about 700° in an auxiliary furnace until all the test-pieces have been withdrawn.

The pieces are then allowed to cool at the normal rate of the furnace. The contractions are measured from distance apart of vertical markings. The porosities are also determined. Curves with temperatures as abscissæ and contractions as ordinates show approximately the firing temperature required to obtain maximum contraction of the clay. (Colour changes should be noted.)

VI.

Tensile Strength of Dried Clays.

Tensile strength is measured by the resistance which the dried clays offer to being pulled apart.

It is exceedingly difficult to prepare clay satisfactorily for this test. Prepared clay must be free from air blebs and laminations; the briquettes must have a homogeneous texture in all directions, and after drying must be free from cracks.

A machine is used such that when shot is run slowly into a loading tin, multiplying levers increase the tension on the test-piece until it ruptures. Tensile strength in lb. per sq. in. =

$$\frac{\text{Wt. of shot} \times \text{machine constant}}{\text{Area of fracture in sq. in.}}$$

The average of five or six tests is necessary for each clay.

VII.

Determination of the After-Contraction or After-Expansion of Refractory Materials.

The term is used to denote the approximate change in size which a brick is likely to undergo when in use at high temperatures.

The temperature for testing recommended by the Gas Engineers' Specification is equivalent to cone 14 (1410°) for material con-

taining under 80 per cent. of silica, and cone 12 (1350°) for bricks containing more than 80 per cent.

A rectangular piece 3 inches long and 1—2 inches in width and depth is cut from the sample; the opposite ends are ground parallel on an emery or carborundum wheel, and the length is accurately determined. The piece is fired until the proper cone squats, and it is maintained at this temperature for two hours. When cold, the length of the test-piece is again determined and the alteration in size calculated.

VIII.

Determination of Normal Refractoriness of Firebricks, Fireclays, etc.

A representative piece of the material is chipped or shaped into the form of a cone about $1\frac{1}{2}$ inches in height. The cone is cemented to the centre of a refractory disc about 2 inches in diameter by means of a mixture of ground bauxite and fireclay; Seger cones are cemented round the test-piece. The cones are chosen in the order of increasing temperatures, according to the material being tested; they should be sloped slightly in an outward direction, so that they will not fall on the test-piece when they melt. The disc is placed on supports on the lifting table of a Hirsch or similar electric furnace.

The temperature of the furnace is increased regularly so that the cones melt at intervals of at least five minutes.

The temperature at which the test-piece bends over, squats, or shows signs of fusion is taken as the softening point, and is deduced from the cone which bent down last.

IX.

The Refractory Test under Load.

A test-piece is cut from a brick and ground to a rectangular block $3\frac{1}{2}$ inches long and 2 inches cross-section, thus presenting a surface of 4 square inches to the load. It is placed centrally on a refractory support in the inner tube of the furnace with Seger cones round it. A cube $2\frac{1}{4}$ inches square, made of similar material to the bottom support, is placed on top of the test-piece; this is followed by a magnesite cylinder and then by a carbon rod. The carbon rod is mounted in an iron ring and attached to a lever arm which comes outside the furnace. By means of the lever, pressure may be applied to the test-piece.

The rate of heating of the furnace is controlled by variable transformers and resistances.

When the squatting of the test-piece has reached the limit decided upon, the current is switched off, the weights, lever, and supports are removed, and the cones observed.

X.

The Thermal or Reversible Expansion of Refractories, or the Hot and Cold Sizes of Firebricks.

The thermal or reversible expansion is conveniently measured by Coppée's apparatus. This consists of a horizontal cathetometer with a standard metre scale for measuring the amount of expansion, and a furnace in which the bricks may be heated.

Two saw cuts of not less than 1 inch in depth and $\frac{1}{2}$ inch from each end are made on the 9×3 face of the brick. Thick platinum wires are placed in each cut with a pointed end projecting $\frac{1}{4}$ inch above the brick.

The distance between these pointed ends is measured by means of the cathetometer for various temperatures of the furnace as estimated either by Seger cones or an optical pyrometer, and the expansion deduced.

XI.

Crushing Strength Cold.

The crushing strength is measured by means of a rotary crushing machine. A Weber's machine proves very satisfactory. (Diagrams and method of using are given.) A. M. J.

272. Silica Products. I. Raw Materials. A. BIGOR (*Trans. by J. A. AUDLEY (Trans. Cer. Soc., 1918, 17, 259).*)—The manufacture of silica products presents difficulties, because of the variety of siliceous raw products and the different ways in which they behave in the fire. The study of siliceous rocks destined for the manufacture of silica bricks proceeds along three lines:—(1) analytical studies; (2) physical studies; (3) micrographic studies.

(1) *Analytical Studies.*—Siliceous rocks include quartz materials, flints, and quartzites. Analyses of quartzite show it to be a mixture of quartz and calcareous clay. The grinding of a quartzite sets at liberty clay which in the presence of silica and a small quantity of lime forms a plastic mass which begins to vitrify and to contract from 1250° onwards, producing a compact and tough mass which envelops the grains of quartzite and gives stability to the product.

When using quartzites for the manufacture of silica bricks it is therefore necessary to analyse and investigate the quantity of clay and use a proportion of impalpable material in order to obtain a more compact product.

Alumina plays the part of a flux in these products; it is indispensable.

(2) *Physical Studies.*—The first test consists in raising the siliceous rock material to the temperature at which the trial piece bends down, and then letting it cool slowly.

In practice, samples are taken weighing about 100 grams, and they are brought in four or five hours to a temperature of 1710°, kept at that for one hour, and then allowed to cool for two or three hours before coming out of the furnace. During this operation, the siliceous rocks have undergone their maximum elongation. After the operation, the rocks may have:—(1) Melted, when they contain alkalis or excess of alumina, and are not suitable for bricks, (2) remained unmelted and (a) remained compact with few cracks; (b) fallen into powder or friable grains; (c) completely severed into larger or smaller pieces; (d) broken uniformly into more or less compact pieces.

The rocks which remain neither compact nor tough after heating to 1710°, are immediately eliminated as unsuitable for brick manufacture, for they would disintegrate spontaneously in the furnace.

Elongation.—Siliceous rocks begin at 1200° to undergo an expansion, which increases by degrees up to 1710°. Certain quartzites heated to 1710° undergo an expansion which exceeds 9·5 per cent. and is under 10 per cent.

Manufacturers should choose products with the lowest expansion to avoid exaggerated expansion of the bricks.

Density.—As silicas expand, their density diminishes. Le Chatelier and Candlot's apparatus permits of rapid determinations being made.

Porosity.—Under this name is signified in practice the ratio between the weight of water absorbed by the material and the weight of that dry material.

Expansion and porosity curves are given showing that samples of flint and quartz expand less and have smaller porosity than quartzites. In spite of this, quartzites give better results in the manufacture of silica products because the interposed clay which they contain constitutes an agglomerant.

(3) *Micrographic Studies.*—A natural quartzite examined under the microscope shows the presence of small silica crystals locked into one another and surrounded by an amorphous sheath. The latter is argillaceous matter. After heating to a high temperature, the silica has been transformed into *tridymite* and *cristobalite*, and under the microscope cracks are observed in the whole mass. It may be the number and dimensions of these clefts which provoke different expansions in the quartzites. A. M. J.

273. The Constitution of Silica Bricks. ALEXANDER SCOTT (*Trans. Cer. Soc.*, 1918, 17, 459).—The paper gives an account of the micro-examination of used and unused silica bricks and of the conclusions derived from the results.

So far as our present knowledge goes, the properties requisite in a quartz rock for the production of silica bricks are:—(1) high content of silica; (2) presence of a small quantity of impurity (preferably under 5—6 per cent.), insufficient to lower the refractoriness appreciably, but sufficient to accelerate the conversion of the quartz; (3) type of structure such as will give angular frag-

ments on crushing, since a brick with rounded rock fragments, like an analogous sandstone, will have lower mechanical strength.

In addition, the usability of a brick depends also on certain factors involved in the manufacture, that is, grain size and grading of material, type of bond added, and duration and temperature of firing. Comparatively little is known concerning the relative effects of the various impurities in silica. Alumina and lime react with excess of silica to form sillimanite and calcium metasilicate respectively. The melting point of the former is 1810° and of the latter 1540° . Ferric oxide does not combine with silica to any extent; it is generally found in the brick in the form of hæmatite or magnetite, or possibly a solid solution of the two. If the brick be subjected to a reducing atmosphere, however, the easily fusible ferrous orthosilicate, *fayalite*, may be formed. The transformation of quartz into *tridymite* and *crystalobalite* is greatly accelerated by the presence of a flux which dissolves the quartz; calcium silicate is more potent than aluminium silicate (due probably to its lower melting point and greater ability to dissolve quartz). Experiments prove the existence of not fewer than seven crystalline modifications of silica; each of these is present in a brick at some stage of its history.

Quartz, *tridymite*, and *crystalobalite* each exist in at least two forms, α and β . The $\alpha \rightarrow \beta$ inversions are reversible and occur with great rapidity. A cold brick contains the α -forms, but at high temperatures it is the β -forms that are present.

Most bricks, as put on the market, contain much residual quartz. Analyses of British, German, American, and Swedish bricks were given, and show that although the structure of the original rock has a fairly strong influence on the conversion of quartz, the latter may be assisted by improved firing. In practice, a brick is rarely at a uniform temperature throughout its whole mass.

Evidence tends, according to the author, to confirm the idea that *tridymite* is the stable form of silica up to at least 1550° .

Bricks containing about 97 per cent. of silica are practically all *tridymite* after being at this temperature for prolonged periods.

Where the bricks have been contaminated by foreign material, the effects vary with the nature of the latter. Bricks subjected to attack by volatilised alkalis showed a greater tendency to the formation of glass. When the foreign materials have been mainly iron oxides, the bricks exhibit several distinct layers, in which the amount of unaltered quartz diminishes as the hotter parts are approached, while the amount of visible *tridymite* increases.

The iron is usually found in the brick as magnetite; one notable point is that the hottest part of the brick is usually grey in colour and contains decidedly less magnetite than the second zone, which is black.

While microscopic examination of used bricks may not lead to many results which are directly of importance to the maker or user, it gives some clue as to the nature of the reactions between the refractory material and the corroding agents. A. M. J.

274. Notes on the Laboratory Testing of Silica Brick.

R. J. MONTGOMERY and L. R. OFFICE (*J. Amer. Cer. Soc.*, 1918, 1, 338).—The recent unusual demand for silica brick has brought upon the market a number of new brands and led to the investigation of various kinds of raw materials in order to determine their suitability for the manufacture of such bricks. In addition to the typical ganister rock, a number of other siliceous materials, such as chert, sand, rock, and materials varying from a fair ganister to quartz sand, loosely bound together, are being tried. At present there are at least two grades of silica brick on the market. The distinction between these grades is not sharp, and their classification varies with the purposes for which the bricks are used. In testing silica bricks, it must be remembered that they differ from fire-clay bricks in being composed almost entirely of one substance. Therefore the properties of the silica used govern the properties of the silica brick.

For control work, the value of chemical analyses is doubtful; but it is of great assistance in determining the purity of the raw material used. The ordinary deformation test, using standard pyrometric cones, is of value. The authors hold that the load test is only of value for the testing of new brands of brick. The crushing strength (cold) of a silica brick is a means of determining the quality of the bond. The specific gravity is also determined, as this test has proved of value in the detection of under-burning. The variation in the porosities of burned silica brick is slight, and little can be gathered from this determination. Quite a number of other tests, such as slagging, spalling, impact, etc., have been used, but the authors have not enough information to warrant their detailed discussion.

The effect of impurities is important. Thus, if the lime content is less than 2 per cent. the bond will be weak, and if higher the refractoriness of the brick will be lowered. Alumina, introduced in the form of clay or other silicates, is probably the most active of all the fluxing impurities present in a silica brick. It should not exceed 1.50 per cent. Its presence in excess of this amount is easily detected by a softening point below cone 32; this, however, is not a proof of an excessive alumina content. Ordinary iron discoloration seems to have less effect on the refractoriness of a silica brick than would be expected. The iron present seems to become saturated with silica and remains relatively inactive. The content of iron should not, in most cases, exceed 1.5 per cent. Other impurities which are found present in very small amounts are not usually considered to affect the properties materially.

Tests were made by the authors in order to ascertain safe operating temperatures. Owing to its high conductivity, the whole brick does not reach the temperature of the furnace. It was concluded that silica bricks may be subjected to higher temperatures when laid in a furnace wall in actual practice than when isolated, but the factor of safety lies only in the fact that the bricks do not attain the furnace temperature throughout.

C. M. M.

275. **Carborundum Refractories.** S. C. LINBARGER (*J. Ind. Eng. Chem.*, 1918, 10, 847).—At the present time there are two types of crystallised carborundum refractories which have been highly developed. The first type goes under the trade names of "Kefrax" and "Silfrax," according as crystallisation of the aggregate is large or small. It is made according to patents which in general cover the silicidising of mixtures of carbon and silicon carbide or carbon forms and their subsequent conversion into carborundum by subjecting the carbon to silicon-containing vapours at the temperature of the electric furnace.

"Carbofrax" is the type most generally applicable for use in the ceramic industries. It is made by bonding graded crystallised carbide of silicon grains with various percentages of a mixture of special refractory clays or other bonding substances.

Crystalline silicon carbide is formed at 1840° and is dissociated at 2240° into its elements, the silicon being volatilised and the carbon remaining as graphite. No softening or fusing occurs below the dissociation temperature, which is shown by the sharp and perfect forms of graphite pseudomorphs which are left when silicon carbide is dissociated. This is in direct contrast to most other refractories, such as silica, chrome, and fireclay brick, which soften at a temperature several hundred degrees lower than their fusion point.

A comparison of the thermal conductivities of common types of refractory materials reveals the fact that the carbofrax brick will conduct heat about three times faster than magnesite, seven times faster than saggar clay mixture, and twelve times faster than a silica brick.

Apart from the importance of fuel economy, the high thermal conductivity and heat capacity of crystallised carborundum impart to refractories made from it the property of withstanding the most sudden temperature changes, because any variation in the temperature of the surface is quickly communicated to the whole mass and the heat rapidly dissipated. Thus the molecular work resulting from it is uniform, and refractory shapes of this type can be subjected to the most sudden variations of temperature without being cracked or disintegrated.

As silicon carbide is not subject to any molecular changes, being formed at 1800° in a crystalline state, and has an extremely low coefficient of expansion, no porous structure is necessary, and a high density can therefore be obtained.

Again, owing to their extreme hardness, this type of brick does not suffer from deterioration as do the common refractories when struck by the tools of the firemen during the process of cleaning the fires.

Refractory materials made of mixtures containing silicon carbide are now being used in various capacities in the ceramic as well as the metallurgical industries. When the thermal efficiency and the increased permanence of structures made from it are recognised, it promises to have a much wider application in the burning of ceramic wares.

C. M. M.

276. The Clays of Florida. E. H. SELLARDS (*J. Amer. Cer. Soc.*, 1918, 1, 313).—A paper giving an account both of the geology and uses of Florida clays. Those in use include brick and tile clays, the white-burning ball clays or plastic kaolins, and fuller's earth. All that are being utilised are found in the northern part of the State—within 200 miles or less of the north line.

No clays suitable for making vitrified brick have been located within the State.

The Florida kaolin-bearing formation is plainly sedimentary in origin, and represents, as indicated by the rather coarse sand with which it is intimately associated, a relatively near-shore accumulation of material. The association of the finely divided clay with the coarse quartz and the mica is one of the problems of this formation.

All the plastic kaolin produced in Florida is shipped out of the State, and is used chiefly or entirely in mixing with other clays, for which purpose it is of value because of being plastic as well as white-burning and refractory.

C. M. M.

277. The Properties of some Ohio and Pennsylvania Stoneware Clays. H. C. SCHURECHT (*J. Amer. Cer. Soc.*, 1918, 1, 267).—This paper deals with the occurrence and the following properties of clays mined in Ohio and Pennsylvania: drying shrinkage, water of plasticity, shrinkage water, pore water, rate of slaking in water, and the transverse strengths in the green condition.

Comprehensive tables, too detailed for abstraction, are appended. It was concluded that, with but few exceptions, the screening of the clays through a 150-mesh sieve improves the strength in the raw and burned condition, increases the dry porosity, lowers the vitrification range, decreases the minimum burned porosity, increases the burning shrinkage, and increases the density in the burned condition.

C. M. M.

278. The Effect of Load on the Refractoriness of Firebricks, etc. J. W. MELLOR and W. EMERY (*Trans. Cer. Soc.*, 1918, 17, 360).—The present report is a continuation of that presented in 1916 (*Trans. Cer. Soc.*, 1916, 15, 117). Two important empirical facts were then established for fireclays: (1) The refractoriness of a fireclay under load diminishes as the load increases in accord with the rule: refractoriness = Ce^{-kw} , where C denotes the refractoriness not under load, W the load in lb. per square inch, and k = a constant characteristic of each fireclay. (2) The sensitiveness of a fireclay to load is greater the greater the alumina content, and less the greater the silica content of the clay.

When extending the investigation to bricks, the furnace and method of procedure are described in Abs. 271 (p. 167). The need for keeping the interior and exterior of the test-piece at as nearly the same temperature as possible limits the size of the test-piece.

If the test-piece be not greater than 1 square inch in sectional

area, there are difficulties with pieces containing coarse grog, for such pieces are unduly weak mechanically.

The flux or matrix which binds the constituents of the firebrick together is quite different in the grog from what it is in the clay, even though the grog is made from the very same clay as is subsequently used for making the bricks. This is due to the fact that in the grog the fluxes of the clay have dissolved so much of the less fusible constituents that it is less fusible and more viscous than the flux in the original clay.

Firebricks with coarse grog are liable to break down mechanically by a diagonal shear, whereas with fine grog the collapse appears as if the actual fusion temperature is reduced. During the burning of the firebrick, the clay does not get so good a grip with coarse grog as it does with fine grog.

Tests show that silica bricks stand up under load very much better than firebricks made from fireclays, but the finer-grained silica bricks do not stand under load so well as the coarser-grained silica bricks. Very fine-grained bricks show as large a difference between the normal refractoriness and the refractoriness under load as bricks made from fireclays. Firebricks under load appear to break down in one of two ways. In one type of collapse (fusion collapse) the bricks gradually give way until the piece collapsed altogether. This is typical of aluminous and zirconia bricks. In the second type of collapse (mechanical) the firebrick may show signs of a gradual deformation, but the characteristic feature is a more or less abrupt collapse. This is typical of silica and siliceous bricks, and to a less degree of magnesite and chromite bricks.

Taken generally, the tests show that the smaller the proportion of fine grog to clay the higher the refractoriness under load. There is also indication of the possibility of a maximum effect being obtained with a particular proportion of fine grog and clay, and that this maximum will vary with each clay.

Similar remarks apply to the medium and coarse sizes of grog, but the effects are less marked.

In fifteen sets of experiments, increasing the size of grog had no specially marked effect on seven of the sets: it decreased the refractoriness of five of the sets, increased the refractoriness of one set, and showed a maximum in two sets.

Other experiments showed definitely that the higher the temperature at which a brick is fired the more refractory does it become under load.

A. M. J.

279. Note on a Firebrick from the Crown of an Electric Steel-melting Furnace. W. J. REES (*Trans. Cer. Soc.*, 1918, 17, 248).—Firebricks made from a newly-discovered bauxite clay which overlies the Millstone Grit lavas in N.W. Ayrshire were found to render better service when used for the crown of a half-ton Greaves-Etchells electric steel furnace than did high-grade silica bricks under similar conditions. The clay is very hard and well jointed, has a conchoidal fracture, and contains very numerous

spherulites of bauxite. It is almost non-plastic, so that on making it into bricks, etc., it is necessary to use a proportion of a refractory plastic clay as a bonding material. Samples from various locations have been found to contain up to 50 per cent. of alumina and 10 per cent. of titanite oxide, and to have softening points from cones 32 to 38. An analysis of a brick, softening at cone 37, gave the following results:—

Silica	51.83	per cent.
Alumina	38.73	” ”
Titanic oxide	6.68	” ”
Iron oxide (Fe ₂ O ₃)	1.56	” ”
Lime	0.31	” ”
Magnesia	0.19	” ”
Potassium oxide	0.59	” ”
Sodium oxide	0.32	” ”
	100.21	” ”

A. M. J.

280. Refractory Materials in Gas Works, from a User's Point of View. J. P. LEATHER (*Trans. Cer. Soc.*, 1918, 17, 244).—

The author deals with certain primary characteristics required throughout the walls, producers, regenerators, combustion chamber, and retorts in a gas works. (1) The parts must have a capacity to resist, throughout a considerable period, deformation by pressure when exposed to an elevated temperature. (2) The parts should not vary in size other than by the unavoidable dilatation with heat. (3) The material should withstand the chemical action of dust, slag, and reducing atmosphere at elevated temperatures. (4) The material should have great tenacity, especially in the producer where the slag runs down and has to be removed by the process of clinking. (5) In the regenerator and in the walls of the retorts greater thermal conductivity is desirable if it can be obtained without countervailing disadvantage. (6) In order that the retort shall not crack with sudden change of temperature, as on the sudden introduction of cold coal, the standard specification demands a certain degree of porosity.

For carburetted water-gas plants, where the chequer-work of superheaters or fixing chambers is subjected to the action of oil vapour, the bricks should withstand any liability to disintegrate.

Regular size and accuracy of shape in fireblocks and bricks is desirable. Variation in temperature alone is a severe test of brickwork, and should be a point to be kept in view when drawing up refractories specifications.

A. M. J.

281. Note on Electric Furnace Treatment of Refractories.

R. S. HURTON (*Trans. Cer. Soc.*, 1918, 17, 236).—The author urges the application of the electric furnace to the preparation of refractories and the firing of products made from them, and asks if it is too much to hope that bricks and other articles may in a short time be made from highly refractory bodies and guaranteed as having been fired subsequently at 2000°.

By processes of selective reduction, it is possible that raw materials could be purified, and so rendered more refractory; at the same time, the electric furnace would offer greater facility for shrinking the materials.

Many of the simple types of vertical arc furnace, as used for calcium carbide manufacture, could be employed, and advantage taken in the design to enable the ore itself to form the effective furnace lining. Some types of electrical calcination furnaces are described and discussed; also some details are given of an electrically heated plumbago crucible.

A. M. J.

282. On the New Refractory and Abrasive Matter called Corindite. A. BIGOT (*Trans. Cer. Soc.*, 1918, 17, 267).—In 1914, a French engineer, Noel Lecesne, took out a patent for a new process permitting the fusing of bauxite in a very economical manner.

Two varieties of bauxite, white and red, are very abundant in the south of France. Two average analyses are:—

	White bauxite.	Red bauxite.
Alumina	59.20	60.10
Combined water	14.10	14.20
Titanic oxide	3.50	3.30
Silica	18.50	2.85
Iron oxide	4.70	21.55

The Lecesne fusing process is identical for the two varieties, and consists in heating in a cupola oven a mixture of bauxite and anthracite and blowing air into the lower part.

Under the influence of the fire and the combustion gas, the bauxite is reduced, aluminium carbide formed, and this in the presence of surplus air is transformed almost entirely into alumina, which is found on cooling as small crystals disseminated throughout the solidified mass.

The products obtained have been subjected to analyses after having been freed from the metallic parts by means of a magnet.

	White bauxite fused.	Red bauxite fused.
Alumina	68.80	69.25
Titanic oxide	3.85	3.70
Silica	21.40	3.00
Iron oxide	5.25	23.35
Carbon	0.60	0.50
Loss on ignition	0.10	0.15

The fused bauxite has been designated by the name of *corindite*, on account of the crystallised mass of corundum. White fused bauxite is a very refractory substance. Red fused bauxite resembles emery in its composition; it is a powerful abrasive.

Corindite has a higher melting point (about 1950°) than the bauxite which served to make it. This is because the iron oxide

has passed almost entirely into the ferrous state, and a *spinel*, $Al_2O_3 \cdot FeO$, formed, resisting a very high temperature.

Crushed corindic mixed with a suitable refractory binder, such as bauxite, kaolinic clay, etc., is used for the manufacture of fire-bricks. Such bricks are found to possess:—(1) very high refractory power; (2) the quality of showing practically no variation in volume up to 1750° ; (3) very great resistance to wear (greater than non-fused bauxite or magnesia bricks).

There exist in Ireland considerable deposits of white bauxite relatively poor in alumina, and up to the present useless. Bricks made of this fused Irish bauxite have been tried with success, although the refractory power is lower than with the French product.

Red fused bauxite is not as abrasive as natural or artificial corundum (90—92 per cent. alumina), since it only contains 70 per cent. alumina, but it is superior to emery. It is suitable for the manufacture of special wheels less hard than those of corundum.

The manufacturing price of red fused bauxite is lower than that of white, red bauxite being very cheap. A. M. J.

283. The Deterioration of Moulds during Storage.

J. W. MELLOR (*Trans. Cer. Soc.*, 1918, 17, 331).—Partially used plaster of Paris moulds on storing often grow a fur on certain parts of the surface. The fur is derived in part from the slip and in part from the mould itself.

If sodium carbonate or silicate or a mixture of the two salts has been added to the casting slip, a small proportion of these two salts, along with the soluble salts of the clay, will be carried into the substance of the mould.

As water works its way from the interior of the mould on drying, it will carry soluble matter along the capillary pores of the mould, and, evaporating on the surface, slowly deposit the soluble matter as a fur or scum.

Plaster of Paris is slightly soluble in water, but much more so in water carrying certain substances, such as phosphates, in solution.

The author is of opinion that casting slip thinned by the addition of a mixture of an alkaline carbonate and silicate exerts a greater solvent action on plaster moulds than when the alkaline salts are absent; as, however, the mould absorbs less water per cast with these salts present, it has a longer life than when ordinary slip is used.

Moulds during storage not only develop a fur or scum, but sometimes they become rotten and readily disintegrate when they are again brought into use. This seems to be due to the growth of crystals, which exert a pressure tending to separate the adjoining parts of the mould, even though free to grow in other directions.

If damp moulds are rapidly dried, the crystals will be small, but will be larger if the drying is slower.

Moulds, therefore, must be thoroughly dried throughout their whole mass before storing, and they should be dried as rapidly as possible. The store-room should be dry and, if practicable, warm, so as to prevent the condensation of moisture on the surface during muggy weather.

A. M. J.

284. The Dissociation of Salt. H. V. THOMPSON (*Trans. Cer. Soc.*, 1918, 17, 340).—The paper records the results obtained in a series of experiments made to determine the hydrolysis of salt in the neighbourhood of 1100° , with the production of caustic soda and hydrochloric acid.

A full description of the apparatus is given, and under the conditions of experiment the author found that the average amount of salt carried by the dry air was 0.0554 gram per litre, and by the air saturated with water vapour 0.0782 gram per litre.

Experiments were also made to ascertain the effect of a stream of air charged with water and salt vapour on some of the more important constituents of clays, namely, silica, alumina, and iron (ferric) oxide.

Action on Silica.—Selected chips of quartz were exposed to the action of salt and water vapour for periods varying up to six hours at approximately 1100° . In all cases, the quartz had lost its glassy appearance, being of an opaque, white colour, while the sharp edges and rough faces had become smooth. The reaction was only superficial.

It is probable that a thin film of molten salt is first deposited on the quartz, whilst the sodium hydroxide produced through hydrolysis by the action of water vapour forms a sodium silicate insoluble in water. The composition of the glaze expressed in gram-molecules of the two oxides is $1.000\text{Na}_2\text{O}$ to 1.023SiO_2 .

Action on Alumina.—Alumina became coated with a layer of fused salt, at times several mm. thick, with an unaltered core of alumina. The salt layer was partly NaCl, but analysis also indicated the formation of a sodium aluminate of the empirical composition $2\text{Al}_2\text{O}_3, 9\text{Na}_2\text{O}$.

Action on Iron (Ferric) Oxide.—Commercial ferric oxide was heated with salt for twelve hours at 1169° ; much salt had volatilised, and the ferric oxide had been converted into magnetic iron oxide (Fe_3O_4), whilst numerous black, shining crystals had been formed in the mass. (Analysis showed that the crystals were also Fe_3O_4 .) A small trace of ferric chloride had also been formed.

Without salt, the iron was only partly converted into magnetic iron oxide, and no crystals of this oxide were formed, consequently the crystallisation must be due to the presence of salt.

Action on Clays.—No attempt was made to study in detail the nature of the changes produced, but it was apparent that a more deeply seated action ensued than in the case of the pure constituents. Moreover, the effect seemed to be greater as the iron content in the clay increased, and in the case of a highly ferruginous earth incipient fusion was discernible.

Reference was also made to the problems attending the use of "salty coal" and the attack of the salt on the refractory linings of furnaces.

A. M. J.

VII.—Chemical Analysis.

285. Colorimetric Test for the Determination of Organic Impurities in Sands. D. A. ABRAMS and O. E. HARDER (*Chemical Engineer*, 1917, 25, 9).—Two hundred grams of dry sand are treated with 100 c.c. of 3 per cent. solution of sodium hydroxide and digested with occasional stirring for twenty-four hours. The extract, which ranges in colour from pale yellow to deep red, almost black, when the sand contains organic matter, is filtered through a filter-paper and refiltered if necessary, since the filtrate must be quite clear. Ten c.c. of the filtrate are placed in a Nessler cylinder, diluted to 50 c.c. with distilled water, and well shaken. The colour is compared with that of a freshly prepared alkaline sodium tannate solution. Ten c.c. of a 2 per cent. solution of tannic acid in 70 per cent. alcohol are added to 90 c.c. of 3 per cent. sodium hydroxide solution and allowed to stand for twenty-four hours. From 1 to 10 c.c. of this solution are measured into Nessler cylinders and diluted to 50 c.c. with water. The colour value in parts of tannic acid per million of sand is one hundred times the number of c.c. of alkaline tannate solution taken to match the colour. It is best to compare the solutions in good sunlight, looking through the whole column of the liquid.

J. D. C.

286. Separation of Iron from Lead. J. F. SACHER (*Chem. Zeit.*, 1917, 41, 245).—This method for the separation of small quantities of iron from lead is based on the insolubility of basic ferric nitrate. Two grams of the lead salt are evaporated to dryness with a moderate excess of nitric acid (sp. gr. 1.15) on the steam-bath, and the residue heated at 100° for fifteen to twenty minutes. The residue then contains the iron in the form of a basic nitrate of the approximate composition $2\text{Fe}_2\text{O}_3 \cdot \text{N}_2\text{O}_5$, or as a hydrate of this compound. Further heating causes a loss of nitric acid and may change the composition of the iron compound, but, as it still remains insoluble, that is immaterial. The residue is then treated with hot water, the insoluble portion filtered off, washed, and the iron in the precipitate estimated by any suitable means.

If the lead compound contains silicates which are decomposed by nitric acid, the residue, after evaporation with nitric acid, must be heated at 130°. Heating at this temperature does not decompose lead nitrate.

When lead sulphate is present, the basic iron nitrate must be extracted with hot ammonium acetate solution prior to dissolving for the estimation of the iron.

The separation of iron from lead by this method is stated to be so complete that the filtrate from the basic iron nitrate does not yield any coloration with thiocyanate.

J. D. C.

287. Rapid Method for the Estimation of Magnesium.

N. BUSVOLD (*Chem. Zeit.*, 1917, 41, 42).—A volumetric method for the estimation of magnesium in limestone is described. From 5 to 10 grams of the mineral are calcined, then dissolved in the least possible quantity of hydrochloric acid, and the solution boiled. An excess of pure calcium carbonate is next added, the mixture boiled, filtered, and the insoluble residue washed. To the filtrate, 20 c.c. of 6 per cent. milk-of-lime are added, the mixture again boiled, cooled, filtered, and the precipitate washed with lime-water. The filter-paper and precipitate are placed in a flask and boiled for five minutes with 300 c.c. of water and 40 c.c. of *N*-oxalic acid solution. The mixture is filtered while hot, and the precipitate washed with hot water. The filtrate now contains the magnesium as magnesium oxalate, together with an excess of oxalic acid.

The free oxalic acid is estimated by titration with *N*/5NaOH, using methyl-red as indicator, and then the neutral solution is acidified with 25 c.c. of dilute sulphuric acid, heated to 70°, and the total oxalate determined by titration with *N*/5-permanganate. The difference of the two titrations gives the oxalic acid equivalent of the magnesium present. One c.c. of *N*/5-solution is equivalent to 0.004306 gram of magnesium oxide.

J. D. C.

288. Analysis of Pyrolusite and other Oxidised Manganese Ores.

O. L. BARNEBEY and G. M. BISHOP (*J. Amer. Chem. Soc.*, 1917, 39, 1235).—Manganese ores usually contain ferric iron, which causes an error in the determination of the available oxygen in the ore by the iodometric method, because ferric salts in acid solution liberate an equivalent amount of iodine from potassium iodide. In neutral tartrate solution, however, ferrous iron is completely oxidised to ferric by an excess of iodine, whilst manganous salts are not affected. The authors apply these reactions to the estimation of available oxygen in pyrolusite. 0.2 gram of a finely-ground and dried sample of the material is treated in a flask with 10 c.c. of *N*-sodium iodide solution and 5 c.c. of concentrated hydrochloric acid. When the reaction is completed, 0.5 gram of powdered sodium tartrate is added, the mixture diluted to 150 c.c., and an excess of sodium bicarbonate introduced. The free iodine is then titrated with standard arsenite solution.

The authors recommend the use of sodium salts in this method, as potassium salts tend to yield a precipitate of potassium acid tartrate.

J. D. C.

289. Estimation of Available Oxygen in Pyrolusite. O. L. BARNEBEY (*J. Ind. Eng. Chem.*, 1917, 9, 961).—The author has examined the oxalic acid method, the ferrous sulphate method, and the iodometric method of determining the available oxygen in pyrolusite.

The oxalic acid method has been found inaccurate. This is mainly due to the decomposition of oxalic acid during the heating period required for the solution of the ore. The decomposition is reduced to a minimum by dissolving at a fairly high temperature in a solution of about 2*N*-acidity. Manganese salts and sunlight greatly accelerate the decomposition of the oxalic acid. The results obtained in 2*N*-sulphuric acid were, however, fairly accurate when the ore was dissolved at a temperature just below boiling.

The ferrous sulphate method was found to be quite accurate; the following working details are given. The ferrous sulphate solution is prepared by slowly adding 200 c.c. of strong sulphuric acid to 900 c.c. of water with stirring, and, while the solution is still warm, 90 grams of crystallised ferrous sulphate ($\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$) are added and stirred until completely dissolved. Prior to use, the solution is cooled to the ordinary temperature and standardised against the solution of permanganate. The permanganate solution contains 10 grams of potassium permanganate per litre, and should be allowed to stand several weeks before use. This solution, which should be standardised by means of sodium oxalate or other trustworthy reagent, is approximately of the same equivalent strength as the ferrous sulphate solution. To carry out an analysis, 0.5 gram of the finely-ground sample is placed in a 250 c.c. Erlenmeyer flask, 500 c.c. of the standard ferrous sulphate solution are added, the flask covered with a watch-glass, and the liquid heated to boiling until solution of the ore is accomplished. The solution is then diluted to about 150 c.c. and the excess of ferrous iron titrated with the standard permanganate.

The direct iodometric method (see Abs. 288 and 290) is equally accurate, but is costly when applied to a large number of samples.

J. D. C.

290. Differential Iodometry. III. Estimation of Available Oxygen in Soluble and Precipitated Oxidised Forms of Manganese. O. L. BARNEBEY and W. C. HAWES (*J. Amer. Chem. Soc.*, 1917, 39, 607).—Ferric iron reacts so slowly with potassium iodide in phosphoric acid solution that it is possible to determine iodometrically various oxidising agents in presence of ferric iron by regulating the acidity of the solution. A method for the determination of available oxygen in the more easily decomposed pyrolusites is based on this fact. From 0.1 to 0.2 gram of sample is treated with 10 c.c. of *N*-potassium iodide solution and 10 c.c. of 2*N*-phosphoric acid in an Erlenmeyer flask covered with a watch-glass, and the mixture diluted to 100 c.c. and left for ten minutes, after which the liberated iodine is titrated.

To use the method successfully, the sample must be ground to

pass a 200-mesh sieve, and if any undecomposed ore is left after the reaction it should be washed by decantation and again treated with phosphoric acid and iodide. Some varieties of pyrolusite, especially those containing much iron oxide, cannot be analysed satisfactorily by this method, and a preliminary test should therefore be made to ascertain if they react without difficulty.

J. D. C.

291. Colorimetric Estimation of Manganese by Oxidation with Periodate. H. H. WILLARD and L. H. GREATHOUSE (*J. Amer. Chem. Soc.*, 1917, **39**, 2366).—Manganese salts are readily oxidised to permanganic acid by alkali periodates in acid solution. In the presence of sufficient free mineral acid, other than hydrochloric acid, to prevent the precipitation of manganic periodates or oxides, the oxidation is complete with a small excess of periodate. The presence of ammonium salts, traces of chloride, a high concentration of acid, prolonged heating, and none of the common metals except those forming coloured salts, interfere with the reaction. Even large amounts of chloride may be expelled by heating with an excess of the periodate reagent.

In using this reagent for colorimetric estimations of manganese, the manganese solution should contain 15 c.c. of concentrated sulphuric acid, 20 c.c. of strong nitric acid, or 10 c.c. of syrupy phosphoric acid per 100 c.c., and be free from reducing substances. About 0.4 gram of sodium periodate is added, the solution boiled for one minute, kept hot for ten minutes, then cooled, diluted, and the colour compared with a standard containing a known amount of manganese and prepared under similar conditions. If the sample contains much iron, the addition of phosphoric acid removes the yellow colour of ferric salts and prevents the precipitation of ferric periodate.

The method gave satisfactory results with test mixtures.

J. D. C.

292. Estimation of Boron in Boron-steel. C. ASCHMAN, jun. (*Chem. Zeit.*, 1916, **40**, 960).—It is found that when boric oxide is heated at 1000° with an excess of ammonium phosphate, the excess of the latter is completely volatilised and boron phosphate remains.

This fact is the basis of the author's method. The boron is distilled from the solution of the steel as methyl borate, and the collected distillate is transferred to a weighed platinum bowl containing 1 gram of ammonium phosphate. The mixture is evaporated, and the residue ignited at 1000° until constant in weight. The amount of boron can be calculated from the weight of the boron phosphate residue.

J. D. C.

293. Estimation of Potassium as Perchlorate. G. P. BAXTER and M. KOBAYASHI (*J. Amer. Chem. Soc.*, 1917, **39**, 249). The authors confirm that the perchlorate method is accurate when

the precipitate is washed with strong alcohol saturated with potassium perchlorate. They point out that where the ratio of sodium to potassium is high, the first precipitate may contain sodium, but this can readily be eliminated by dissolving it in a little water and evaporating again after addition of a little perchloric acid.

J. D. C.

294. A Method for the Colorimetric Estimation of Cobalt. E. G. JONES (*Analyst*, 1918, 43, 317).—A satisfactory reagent was found to be a solution of α -nitroso- β -naphthol, as prepared by Atack (*J. Soc. Chem. Ind.*, 1915, 34, 641); whilst by the addition of ammonium citrate to the solution under examination, the effect of moderate quantities of many other metals on the accuracy of the determination was eliminated. The ammonium citrate solution was prepared by dissolving 500 grams of citric acid in 250 c.c. of water and adding 500 c.c. of ammonia (0.880). This solution contains excess of ammonia.

The solution in which cobalt is to be determined must be free from nitric acid and only slightly acid with hydrochloric acid. It is made up to a convenient volume, an aliquot part transferred to a Nessler cylinder, 5 c.c. of ammonium citrate solution added, the mixture diluted to 95 c.c., 5 c.c. of the α -nitroso- β -naphthol solution then added, and the contents of the cylinder well mixed. The colour of the liquid is matched against different quantities of a standard cobalt solution to which the same amounts of ammonium citrate and α -nitroso- β -naphthol have been added as used with the sample. It is essential that the amount of free ammonia should be nearly the same in the solutions compared. The most satisfactory quantity of cobalt for comparison is found to be about 0.1 mg.

The method has to be modified in the following cases:—

(1) Copper, if present, must be removed by precipitation with sulphuretted hydrogen, filtration, and the sulphuretted hydrogen boiled off from the filtrate prior to the determination.

(2) Nickel interferes, and must be removed by means of dimethyl glyoxime. After filtering off the nickel precipitate, the filtrate is made up to a known volume and an aliquot part transferred to a porcelain dish. This portion is evaporated to dryness and then gently ignited to remove the dimethyl glyoxime. The residue is treated first with aqua regia, then with concentrated hydrochloric acid, and evaporated to dryness; after addition of a drop of dilute hydrochloric acid and extraction with hot water, the cobalt is estimated as above.

(3) If the manganese is present in a quantity not greater than ten times that of the cobalt, it does not interfere with the test, provided the mixture in the Nessler cylinder is allowed to stand for half an hour before being matched.

If much manganese is present, the following procedure is adopted. To the solution containing the metals as chlorides is added an equal volume of nitric acid (sp. gr. 1.2) and a small quantity of

sodium bismuthate. It is then digested on a hot plate until the pink colour disappears and the manganese is precipitated. The precipitate is filtered off and the filtrate made up to a suitable bulk. An aliquot portion of the solution is transferred to a Nessler cylinder, 5 c.c. of neutral ammonium citrate are added, and the liquid neutralised with ammonia, using litmus paper as indicator. Then a measured quantity of 10 per cent. ammonia is added, followed by 5 c.c. of α -nitroso- β -naphthol, and the colour matched against standard cobalt solution containing the same amounts of neutral ammonium citrate, ammonia, and α -nitroso- β -naphthol.

The method works satisfactorily for 1 part of cobalt in the presence of 250 parts of iron or 1,000 parts of zinc.

According to the authors, good results for 0.01 per cent. cobalt can be obtained.

J. D. C.

295. The Colorimetric Estimation of Iron. E. R. DOVEY (*Analyst*, 1918, 43, 31).—In estimating iron colorimetrically by the thiocyanate process, it is well known that in many cases accurate results will not be obtained if the comparison liquid differs much from that under investigation either in thiocyanate content or general composition. By working as follows, such errors are eliminated.

To a measured volume of the liquid under investigation the thiocyanate is added, the liquid well mixed, and two-thirds placed in one Nessler cylinder and one-third in another. Standard iron solution is then added to the smaller portion until the tint is equivalent to that of the larger on looking down the cylinders.

J. D. C.

296. Reagents for Use in Gas Analysis. V. Relative advantages of Sodium and Potassium Hydroxides in preparation of Alkaline Pyrogallol. R. P. ANDERSON (*J. Ind. Eng. Chem.*, 1916, 8, 999).—When the best practicable solutions of sodium and potassium pyrogallate are compared, the specific absorption of the sodium reagent is the higher, and the cost of the sodium reagent is less, even in normal times. The author contends, however, that no real economy is effected by using the sodium reagent, because each analysis with sodium pyrogallate takes about two and a-half minutes longer than would be the case with potassium pyrogallate. He gives figures to show that at the current prices (1916) a saving of three shillings in cost of chemicals involves the expenditure of about thirty additional hours in manipulation.

J. D. C.

VIII.—General.

297. **The Aims of the Jena Optical School.** O. HENKER (*Deut. Mech. Zeitung*, 1918, 73).—The object of the school set up at Jena is to give opticians a technical training. The syllabus of the school is as follows:—

A. **THE SPECTACLE AS OPTICAL INSTRUMENT.**—(a) *The Theory of the Spectacle*, 6 hours weekly. (1) The eye as optical instrument. (2) The stationary eye and the spectacle. (3) The moving eye and the spectacle. (4) Binocular vision through spectacles. (5) Aid for feeble eyes. (b) *The Application of the Subjects of Section (a)*, 10 hours weekly. (1) The spectacle glass and its working. The raw material. (2) Frame and fittings. (3) Precautions (b) *Use and Testing of Optical Instruments*, 6 hours weekly.

B. **OPTICAL INSTRUMENTS.**—(a) *The Elementary Theory of Optical Instruments*, 4 hours weekly. (1) Fundamental optical laws. (2) The photographic objective. (3) Projection apparatus. (4) The magnifying glass. (5) The microscope. (6) The telescope. (7) Various measuring instruments. (8) Ophthalmic instruments. (b) *Use and Testing of Optical Instruments*, 6 hours weekly.

C. **ADDITIONAL SUBJECTS.**—(a) *Photography with special regard to shop practice*. Skill and accommodation necessary for carrying out customers' requirements, 5 hours weekly. (b) *Algebra, Trigonometry, and Geometry as far as is necessary for A and B*, 2 hours weekly. (c) *Meteorology*, 1 hour weekly. (d) *Physics as necessary for A and B*. (e) *Commercial subjects*, 2 hours weekly; *German language and literature*, 2 hours weekly. (f) *Drawing*, 2 hours weekly. In addition, if required, *French or English*, 1 hour weekly.

J. R. C.

Reviews.

The Journal of the American Ceramic Society. *Volume I.*—The American Ceramic Society has steadily grown to one of the important scientific societies in the United States, with a present membership of more than 1,000.

Year by year it has published the papers which have been read to the society in the form of an annual journal, entitled the "Transactions of the American Ceramic Society." The first volume, which appeared in 1899, contained 110 pages, whilst volume XVIII. for the year 1916, had become a substantial publication of 947 pages.

This increase in the number of pages devoted to original papers and discussions is indicative also of the interest which has grown

up in America in the silicate industries, including the subjects of refractories, pottery, clay, and glass. Like the scientific societies devoted to applied science in this country, the war has stimulated interest enormously, and for some time now movements have been on foot to increase both the membership and the general usefulness of the society. With this object, it has been decided to issue in a different form the papers which are contributed to the society, and the monthly journal, which now takes the place of an annual volume of Transactions, is one of the changes instituted.

Each number consists of a series of editorials, original papers, and discussions and announcements of the meetings of the local sections of the society.

A number of papers in the issues already to hand are of considerable interest to the glass manufacturer. For example, in the January number is an interesting paper on "Special Pots for the Melting of Optical Glass," by A. V. Bleininger. In No. 2 Dr. Tillotson has a paper on the "Relations between the Physical Properties and the Chemical Composition of Glass." Another paper in the same number records "Observations on the Formation of Seed in Optical Glass," whilst there are other papers dealing with fireclays and their bonding strengths at different temperatures.

In these days, when our relationships with the United States are being drawn very close indeed, members of this society may like to know that membership in the American Ceramic Society is open to British subjects, the annual subscription being almost identical with that of our own society. The writer will be glad to give information to any member desirous of making further inquiry.

W. E. S. T.

Annual Reports of the Society of Chemical Industry, 1917, Vol. II.—The second volume of this publication shows a considerable increase in size, from about 300 to 500 pages, excluding indexes, over that of Vol. I., and deals with the various chemical industries under twenty-one, as against fifteen, sections in the former volume. The glass manufacturer will find useful suggestions by a perusal of the sections dealing with Plant and Machinery, Fuel, Gas, Mineral Oil, Acids, Alkalies and Salts, Glass, Refractory Materials, Ceramics and Building Materials, Metallurgy of Iron and Steel and of the Non-Ferrous Metals, and each volume as it appears should find a place amongst the works of reference which he purchases.

W. E. S. T.